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Tuan Nguyen

THE SILENT REVOLUTION

THERE'S SOMETHING EXCITING coming this year that I've been eagerly awaiting: faster storage. Those who know me know I archive everything. I love all things storage, including its speed. Which is why Intel's XPoint, which is now referred to as Optane, is so exciting. When Intel initially announced Optane, it said that the new storage technology would deliver performance greater than 1,000 times that of today's fastest NVMe SSDs. This isn't just fast, it's a humiliation of what we have today.

Based on a manufacturing process that employs phase-change memory designs, drives that utilize XPoint technology are poised to deliver a gargantuan increase in both storage capacity and performance. If that's possible, it would be a real challenge to spinning-disk hard drives. Today, if you want large capacity, you still have to really on hard drives, which currently top out at 10 terabytes. XPoint would be the holy grail of storage for me, especially as I use an enormous number of hard drives. This is a problem.

I have to deal with technology on a daily basis, and while it's exciting, fun, and educational, there's just one tidbit that I can't seem to get a handle on: the noise. My home is full of hardware. The worse part of it is, my home office is also part of where I sleep. It's one long room that's divided in half: a bedroom on one side and an office on the other.

I think I've gotten to the point where I've become numb to all the whirring sounds of technology, but it's still bothersome at times, especially when I need to test things such as headphones. Servers, PCs, and cooling equipment all generate noise. I've gotten around to replacing stock fans on products with quieter and lower-rpm fans, but they still generate a noise when everything's on. For most people, their PC is the center of this problem.

Thankfully, we've put together an exhaustive guide for you on how to build a dream setup that's both potent and whisper-quiet. This is typically a dichotomy, because power usually means noisy—just look at cars. And, yes, I know you can get a very quiet Tesla Model SP100D, and humiliate virtually every petro-powered supercar without making a peep. With a little planning and careful selection of components, however, you can achieve the equivalent of a Tesla in the form of a PC.

For my own main rig, I've taken a few tips right out of these pages: silent water cooling, high-quality fans, and an increased reliance on SSDs. I even went as far as to water-cool my graphics card. The possibilities are essentially endless, and I'm happy with the results I've achieved. The only issue is achieving the same levels of silence with the myriads of servers that dwell within my room. This is a challenge that I've yet to tackle.

There will be some point in the future where I imagine my room to be thoroughly water cooled, all storage equipment is solid state, and everything is silent. But that's still a ways off. For now, I'll settle for silencing my PC, and living with 48 spinning hard drives.

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 20 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Ryzen Rules

All we had hoped for is true: AMD has raised the bar for processors with its new architecture

The official reveal: Not much to see, but this is the hottest processor launch for years.

IT'S HERE FOR REAL. AMD's new processor architecture is available, and it's just as fast and as competitive as we'd hoped. AMD has started at the top, by releasing three eight-core chips: the $329 3.0/3.7GHz (base clock and boost) 1700, the $399 3.4/3.8GHz 1700X, and the $499 3.6/4.0GHz 1800X. The "X" stands for eXtreme. Performance is very strong, and at those prices, Intel's Core i7s are starting to look woefully poor value.

Initial benchmarks put Ryzen on a par with or better than Intel's finest (see our review of the 1800X on page 76). The overclockers have already been at play, and one bright spark has produced a world-record Cinebench R15 score of 2,449, achieved at 5.2GHz, with the help of some judicious cooling.

Pre-orders have been huge; currently, the best-selling processor on Amazon is the Ryzen 7 1800X. This has been the most hotly anticipated launch since Intel unleashed the Core 2, in 2006.

Alongside the processors, we have motherboard chipsets for the new AM4 boards—three initially. The A320 is a mainstream chipset, while the B350 is where things get interesting, as it offers overclocking and better USB support. However, the one all eyes will inevitably swivel toward is the X370, which has everything thrown at it, including SLI and CrossFire support, four DDR4-3200 slots, two 16-lane PCIe, and more. Later on, we will see A300, B300, and X300 chipsets all aimed at small form factor builds, with the latter offering overclocking goodness.

Some small wrinkles have emerged. Asus has discovered that there are issues with high-frequency DDR4 memory, making it unstable above 2,400MHz if you use four sticks (although with two sticks, 3,200MHz is fine). BIOS and memory controller fixes are due shortly. Also, despite initial hopes to the contrary, Ryzen is a Win 10-only affair. Face it, you'll have to upgrade eventually.

The more mainstream Ryzen 5 chips are expected in the spring, with the Ryzen 3 family planned for later in the year. These will similarly undercut Intel Core i5 and i3 offerings in price and performance; Intel is facing pressure across the range.

What can Intel do? In the short term, not a lot. There's precious little room to crank up clock speeds on the current Core i7 chips. Most obviously, it can cut prices; at the time of going to press there have been no official price cuts yet, but we suspect you won't have to wait long. Retailers are already discounting like crazy. At Microcenter, the Core i7-6950X has dropped $300, and the i7-6900K by $200. The price cuts run right through the Intel range. Intel's people will be out there now trying to cut deals. The company has an unflattering history here, and has picked up fines for anti-competitive practices in the past, under the guise of counter rebates and such. Let's hope it can keep things clean this time.

For any real response, we have to wait until August, and the launch of Kaby Lake-X and Skylake-X. These are branded as Core i7-7000 series chips, and use a new 2,066-pin socket and X299 chipset. The range will include 10-core versions; rumor has it that Intel is developing a 12-core version, but this is highly speculative. What is clear is that Intel will have to do something. This is not a company that enjoys coming second. It will respond.

Meanwhile, AMD is enjoying a well-deserved moment in the sun. So far, Ryzen has lived up to our expectations—it's hugely fast, and priced to sell. AMD has put itself right back in the game, and caused high-power CPUs to tumble in price. And for that, we can all be thankful. **–CL**

> “
> One bright spark produced a world-record Cinebench R15 score of 2,449 at 5.2GHz.

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WINDOWS CHURNS EVER-FASTER

Say goodbye to Vista, while Win 10 gets two major updates this year

IF YOU ARE RUNNING VISTA, you won't need to be told that support from Microsoft is ending on April 11—you've had an annoying pop-up telling you that for weeks. All updates and security patches will stop, and you'll be on your own. Vista was never very popular; it took some serious patching and Service Packs before it stabilized, installation was cumbersome, and driver support erratic. Sales were poor—according to NetMarketShare, it currently accounts for under 1 percent of the world's PCs. Windows 7 is still the most popular, at over 47 percent—those people have until 2020 before support is pulled. The end of Vista isn't going to be the shock that the death of Windows XP caused. This was so unpopular that Microsoft had to extend support and add XP Mode to Win 7. Vista has had a good 10-year run, and won't be missed.

Do you have to upgrade? Not really. The lack of security updates is an issue, but proper security practice can replace much of that. However, things will slowly become more awkward if you insist on installing new hardware and software. Game and driver support will vanish—Gmail and Blizzard have already announced their withdrawal of support.

Meanwhile, Windows 10 is due for two major updates this year. Along with the Creators Update this spring, we have "Redstone 3" being readied for the fall. It is expected to include Composite Shell, to unify the Windows interface across devices, Project NEON, to animate screen elements, and My People, carried over from the Creators Update, designed to make sharing with contacts a drag-and-drop operation. Windows 10 looks to be on about an eight-month cycle of updates—fairly hectic by Windows standards. **–CL**

ATOM GOES 16-CORE

LOTS TO PROVE FOR NEW IoT CHIP

INTEL'S BABY PROCESSOR, the Atom, has had fresh life breathed into it with the release of the C3000, armed with 16 low-power x86 cores, and clock speeds up to 2.2GHz. It's aimed at NAS and IoT devices, where data throughput is more important than processing power. The previous Atom C2000 has an unenviable reputation for frying itself after a year or two. Details as to why are scarce, but it was a headache for manufacturers.

This also highlights the repositioning of the Atom. It was originally designed with phones and netbooks in mind, but poor performance and even poorer sales caused Intel to drop any attempt at the market last year. It canceled all development of new mobile versions, and wrote off considerable investments. The Atom is now all about network devices. **–CL**

GOOGLE SUES UBER

Claims its technology has been stolen

DRIVERLESS CARS are coming; Uber has started a trial of its new vehicles in Arizona. You might wonder how the company managed to create such complex technological hardware with no previous history, but Uber spent $680 million buying Otto last year, which was developing the tech, including LiDAR, Light Detection And Ranging, the hardware that tracks the car's position.

Otto was founded by ex-Google employees, half of whom were working in Google's driverless car division. Google claims they stole data before they left. It says it has "significant" evidence, including download logs totaling 14,000 files of blueprints and technical data. Uber has issued a denial, but the situation could be very painful for the company, which has been very ambitious to get driverless cars to the streets before anyone else. This case could derail those plans, and prove expensive for a company that already posts alarming losses. **–CL**

Tech Tragedies and Triumphs

A monthly snapshot of what's up and down in tech

TRIUMPHS

SUPER-SLOW MO
Sony has a new image sensor for phones that can shoot at 960 frames per second.

STEAM AUDIO
The new royalty-free audio SDK adds more realistic physics-based sound to games.

GEFORCE 1080 TI LAUNCHES
The latest Pascal-based graphics card offers up impressive 4K gaming, with Titan X-beating performance.

TRAGEDIES

MAC MALWARE
Sophisticated malware and spyware is increasingly targetting the Mac OS, including an all new XAgent.

PC PRICES RISE
Shortages of key components have been blamed for four months of price rises.

GETTING MESSIANIC
Zuckerberg has released a rambling essay on how Facebook is going to make the world better.

Jarred Walton

TECH TALK

Your Computer's Memory Hierarchy

THE CORE OF ANY MODERN PC is the processor—it's the brain that makes everything else work. But just like human brains, the processor depends on other components to keep things ticking along. One aspect of PCs that routinely gets mentioned, without digging into what's really going on, is the memory hierarchy, so I want to discuss cache levels and other parts of the hierarchy, and how they relate to performance.

CPUs perform a lot of repetitive calculations and data accesses—it's not a constant stream of new data. Small segments of code are repeated thousands of times, before moving on to the next block that gets repeated. The memory hierarchy optimizes the flow of data and instructions, a critical task for keeping the CPU fed with the data it needs.

Think of the CPU as the chef at a restaurant. People might order steak and potatoes, fish and chips, a salad, or any number of meals. Each uses a recipe that repeats the same sequence of ingredients and steps. A chef has limited resources, and can only use a few items at any time—cooking utensils, pots and pans, seasonings, ingredients, and so on. Whatever is in his hands can be used immediately, with commonly used items kept close by. But not everything can fit on the counters, so some things are in the cupboards, refrigerator, and pantry, and a larger storage area and meat locker might hold additional stock. And when supplies run low, orders are placed with markets and warehouses.

That's sort of the high-level overview of the memory hierarchy. The hands of the CPU are called registers—they manipulate specific data at any given moment. Unlike humans, processors have way more than two hands. The x86-64 instruction set defines 16 integer registers, eight floating-point/MMX registers, and 16 SSE/AVX registers (plus a few others). So the CPU is like a 40-tentacled monster chef, each tentacle holding data and instructions that it's ready to use, but even 40 tentacles isn't enough, which brings us to the caches.

> The CPU is like a 40-tentacled monster chef, each tentacle holding data and instructions.

The L1 cache is close at hand, with an access delay measured in a few clock cycles (typically 4–5). The CPU tries to predict what data it needs next, and an L1 cache hit means there's no delay with the number-crunching going on. L1 cache size is typically limited, usually 32K or 64K, to keep access times high. It's a huge step up from the total register space of around 512 bytes, but still relatively small.

L2 cache is a larger repository, with current CPUs using anywhere from 256K to 2MB. Unlike the L1 cache, which usually has separate areas for data and instructions, L2 cache holds both types of content. L1 and L2 cache are generally implemented on a per-core basis, to keep latency low, but the larger size makes searching the L2 cache take longer, around 12 cycles—and a 2MB L2 cache would be even longer.

Last is the L3 cache (or on some CPUs, L4/eDRAM, but I'll skip that), which is usually several times larger than L2 cache, and shared among all processor cores. Modern Intel processors have anywhere from 2MB to 25MB L3 cache (more on server parts). AMD's FX CPUs have 4MB or 8MB, but the APUs have no L3 cache; Ryzen has 8MB per four cores. L3 cache latency varies by the size of the cache and other factors, ranging from around 35 to 60 cycles.

After the cache levels comes system RAM, which is like a local supermarket with a huge inventory. But you have travel there, grab what's needed off the shelves, and pay at checkout. RAM accesses are measured in nanoseconds, with DDR4 memory requiring around 50–60ns. That's on top of the L3 delay, so about 250–300 cycles for a 4GHz CPU to pull data from RAM. And heaven help your CPU if it has to wait on long-term storage, such as an SSD or HDD, where delays can be thousands of clock cycles.

So, next time someone starts talking about L3 cache or the memory hierarchy, picture our friendly monster chef, busy at work. Then overclock him, so he can keep up with the orders, because the apps are tired of waiting.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

THE LIST

MAXIMUM PC's TOP 7 KEYBOARDS

7

STEELSERIES APEX M500

($97) At under 100 bucks, this just scrapes in as a good value mechanical keyboard, with its red switches, single LED backlight, and clean plastic chassis.

6

LOGITECH G610

($90) Media keys, Cherry MX Reds, a black frame, a single white LED backlight, plus some fancy controller tech make this an exceptional value-oriented keyboard.

5

DAS KEYBOARD 4C PRO

($113) Everything else too garish? Das Keyboard's 4C Pro should fit the bill. With an ergonomic tenkeyless design, this Greetech mechanical model is perfect for any typist.

4

CORSAIR K95 PLATINUM

($200) The K95 Platinum comes with a whopping price tag, and Brown or "speed" switches. Read the full review on page 85.

3

RAZER BLACKWIDOW X CHROMA

($163) Full-sized, soft touch, and with a custom clicky switch that'll make your dog, neighbors, and wife immediately want to throw a rock at your head. Dedicated media switches would have been nice.

2

CORSAIR K70 LUX RGB

($128) Almost at the pinnacle of its game, the K70 adds USB pass-throughs, Cherry MX Blue switches, and an updated lighting controller. Shame about the gaming font.

1

HYPERX ALLOY

($100) The Alloy is a beautifully cut, aluminum mechanical joy to behold. With an exceptional footprint, a variety of switches, and RGB coming soon, it's a truly divine device.

Alex Campbell

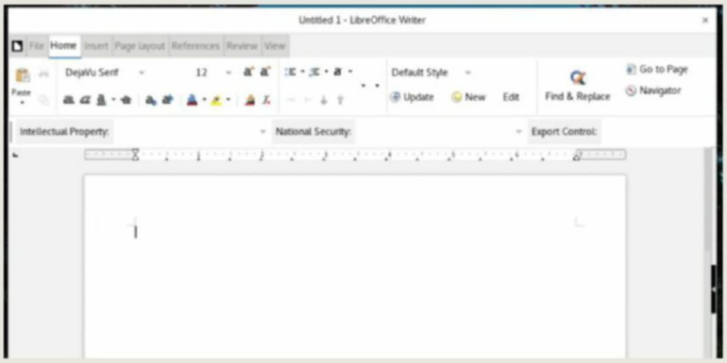
OPEN SOURCE

LibreOffice, Please Meet Office 2007

WHEN YOU HAVE a fresh Linux installation, you can count on a few basics. A browser, such as Firefox or Chromium, a mail client, and a file browser all come stock with a Linux desktop. LibreOffice is another of those included goodies, and it has become one of the core products in the world of desktop free software.

LibreOffice is a far cry from the older and antiquated OpenOffice.org it's forked from, and is a pillar of offline productivity on Linux. After all, it provides word processing, spreadsheets, databases, and presentation applications that enable you to get Real Work™ done. For years, LibreOffice served well as a drop-in replacement for Microsoft Office, with one big caveat: The user interface was kind of, well, fugly. And LibreOffice isn't alone.

Sure, the program could read and do a reasonably good job of displaying and formatting Microsoft Office documents. Sure, it's got Track Changes and other features. Hell, recent updates even introduced support for setting pre-defined and custom classification statuses for documents. (You can create classifications such as "SECRET/NOFORN," for instance.) All of that is great, but it seemed weird with a default interface that looked like it was stuck in 2003. Custom icon themes and other tweaks help, but they can only go so far, and are a pain to set up.



The new LibreOffice showing off the experimental tool "ribbon" UI, while using a Chrome OS-inspired GTK 3 theme.

While I remember the online gripes about the move to a "ribbon" UI in Microsoft Office, most people expect that interface nowadays. LibreOffice's UI team finally arrived in this decade with the release of LibreOffice 5.3 in February. Even with the update, the new UI has to be enabled. (To do this, click "Tools → Options → Advanced," check "Enable experimental features," then click "View → Toolbar layout → Notebookbar.") Even with the new UI layout, some of the default icons still seem a little dated or out of place (though you can always use your own icon theme).

A good UI is nothing to sneer at, even for a hardcore terminal junkie. A user interface determines how most people use an application and connect to it emotionally. As good as Nixnote 2 is as an Evernote client for Linux, the fact remains that the UI for Evernote on Mac OS X and Windows is much easier on the eyes. As beautiful as some GTK and Qt themes can be, they can't always make up for lagging implementations or other shortfalls. The other main staple, GIMP, still uses GTK 2 (though porting to GTK 3 is on the v.3.0 roadmap). Good design encourages the user to use the program, and gets out of the user's way. Many Linux apps do this well, but some just aren't there yet. And I get why: Function often trumps form in the world of open source.

Not everyone will clamor for the new ribbon (I, personally, like the old-school toolbar layout myself), but it may prove a welcome feature for those making the switch over to a Linux system. It will take a while to get the new ribbon code and appearance polished, for sure. But once it's looking good enough to be a default UI, it will be a lot easier to sell LibreOffice's other merits to everyday people. However small, it's certainly a welcome visual update, and I hope that it's an indicator of better things to come for LibreOffice, and free software applications at large.

Alex Campbell is a Linux geek who enjoys learning about computer security.

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TALKING

BY **ZAK STOREY**

PNY on Breaking into the Gaming Market

Jonathan Filleau reveals why gaming is important to the industry, and what PNY can bring to the table

Gaming is a common passion of PC enthusiasts, and it challenges manufacturers to continually push the envelope with their hardware. It's not the only crux upon which computational performance sits, but it's one of the biggest, raking in an astonishing $36 billion every year, so it's easy to see why companies want a chunk of the pie. We spoke to PNY's EMEA marketing manager, Jonathan Filleau, about how PNY is taking advantage of this, and what we're likely to see from the Paris New York company this year.

Jonathan Filleau explains why PNY is so keen to crack the gaming market.

Maximum PC: It's fair to say PNY has traditionally been more oriented towards large-scale businesses and design houses, things like that. Can you give us a little insight as to why you've decided to target the gaming market so aggressively in the last few years?

Jonathan Filleau: So, basically, PNY has been working with gamers for 15 years or so now. We are known both on the professional side, with the Quadro cards, of course, and on the gaming side, which used to be the Verto cards, and is now the GeForce category. We decided to invest a lot—I would say eight years ago—in the gaming industry, because we were looking at the trend, which was really growing. And in the last four years, we have the XLR8 brand, which is kind of a sub-brand within the company, pushing a lot of graphics cards—but not only graphics; DRAM, SSDs, and peripherals. And, at the end of the day, if you think about this, PNY is the only company in the market able to provide this full kind of access to all these components all at the same time. So this is why we decided to provide all of this to the market and invest in all these gaming solutions.

MPC: We've always been a big fan of your memory products, especially your DDR4, as it hits that sweet spot between price and performance that we all love. Talking specifically about SSDs, can you tell us how you go about designing a product, ready to go to market?

JF: So, the design process starts with a strong relationship with our internal engineers, and also with gamers. We take some of the gamers in house, from our own community, or from some people we are sponsoring with the XLR8 brand, and we talk about what they would want to use in their systems. Based on this kind of brief, the marketing team then works with the engineers, trying to find the right speed and the right firmware, because it is not just a question of speed, but also a question of firmware, and what you can provide with a product, and even what endurance you're going to get. So, if you take the example of the CS2211 SSD, which is our gaming model, we spend a lot of time finding the right speed, which happens to

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Check out our review of the CS2030 on page 83.

be 565MB/s and 540MB/s for the sequential read and write speeds, but we also have to spend time on tuning the right firmware and crafting the right packaging, to perfect the overall XLR8 environment.

MPC: Arguably, M.2 PCIe storage is now the next big thing when it comes to advancement in SSD speeds, so what are PNY's plans regarding this platform change? How is the company going to take advantage of this form factor and connection standard?

JF: I'm quite glad that you asked that question, because today we're really happy to announce a new product, which is the CS2030 M.2 by PNY. Of course, it's NVMe compliant, because in our opinion, that's absolutely a file formatting system that you need to be utilizing to be successful in this field. It's M.2, of course. The speeds are 2,500MB/s read and 1,500MB/s write speed. It's a very high-speed drive, and it's going to give an opportunity to our customers to install their operating system, if they have a motherboard that's compatible, or a compatible laptop, on to the drive, and we strongly believe it's going to be a part of the future when it comes to SSD storage. So, we're going to get our storage setup solutions, and our M.2 solutions as well.

MPC: Is it likely that we'll see any U.2 storage coming from PNY in the future, or is that a connectivity standard that's going to be solely limited to Intel at the moment?

JF: As of today, it's not something we have on our development roadmap preparation. We don't really feel the interest of U.2 at the moment on our roadmap, because it's great if you want really, really crazy speed—so it's really great if you're looking for benchmarks—but at the end of the day, PNY is looking for the standard people, buying standard products for their system, for gamers, for high-end gamers, and we strongly believe that M.2 is going to give the same type of results for a better price, so that's why we're not focusing on U.2 solutions.

MPC: Speaking of new connection standards and pursuits into other areas, is there any chance we'll see PNY produce any AMD graphics cards going forward? Obviously, with Vega rumored to be releasing soon, that's going to be a series of cards that are at the forefront of the minds of the vast majority of our readers, not to mention us hardware journalists, too.

JF: PNY has always had a really good historical relationship with Nvidia, and we're really glad to work with it, with this company. Nvidia has always been the first one with the innovation and the technology, and always in advance of its competitors, which is exactly what the final customer and the gamer is looking for. So, this is exactly where we want to go, this is where we are, and that's why we're really happy to continue with Nvidia.

MPC: The XLR8 GTX 1080 impressed us with its triple-fan cooling, its plug-and play-design, and its general performance as well. However, I think a lot of us were a little disappointed there was no aftermarket software support. Is that something we may see any time soon?

JF: No, because PNY has always wanted to come with a ready-to-use solution for the final customer. So, that's why our decision was to provide something that was already overclocked, ready to install, and ready to use. We are spending a lot of energy on the quality of the components and the quality of the PCB, and we are always following Nvidia's PCB guidelines and design. So the hardware is really our part—for the software, we prefer to have everything fixed in place, to avoid any issues for the final customer, and have everything ready to use.

MPC: With Nvidia's Volta allegedly launching later this year, can you give us any hints at all about what advances you will be introducing with your next generation of card? Is RGB lighting going to be there, for instance, or perhaps a new design of cooler?

JF: It's very difficult for me to talk about them right now, because we don't have access to those plans just yet. But what I can tell you is that compared to what we've just done with the XLR8 GTX 1080 and 1070, we're going to continue to spend effort and marketing energy on the fans, on the cooling system, on the components on the card. So, if you look at our overclocked versions, this is something we're going to do on our next generation. We've done triple fans on the GTX 1070 and 1080, and dual fans on the GTX 1060 and 1050 Ti, so we'll definitely still be working on that. RGB is a very interesting question—this is something we have in our development team, with our brainstorming sessions; this is something we're definitely investing in, in the future, as we believe this is definitely something that can be added value on the graphics, but maybe also on those other kind of accessories.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Win 10 Installation
> USB Drive Recovery
> WWII Flight Sims

Installing Windows 10

Hi Doc, I'm planning to build a desktop PC, and would like to know the best way to install Windows 10 on an SSD. I'm thinking about buying a 1TB Samsung drive based on the M.2 form factor. To start, I only want one, though I might upgrade later. The storage would likely drop on to an Asus X99 platform or something similar. I'm in the market for an Intel Core i7-6600K and 32GB of DDR4-2666, too.

Please let me know how all of that would work together. I'm leaning toward purchasing a Windows 10 disc. **–Ken Payne**

THE DOCTOR RESPONDS: Before the Doc gets to your question, Ken, there is no Core i7-6600K. There's a Core i5-6600K, but it drops into an LGA 1151 interface and is not compatible with Intel's X99 platform controller hub. Perhaps you meant Core i7-6900K?

Microsoft sells Windows 10 as a download or on a USB flash drive. If you choose the former, a media creation tool on the company's site loads the ISO file on to a flash drive or blank DVD, enabling you to boot from solid-state storage or optical media, and install the OS.

Asus sells several X99 motherboards with M.2 connectivity, and a 1TB Samsung SSD should be sufficiently roomy and fast.

Most of Asus's X99 mobos support M.2 solid-state drives.

Stuck in the Slow Lane

Hi Doc, I have an Asus VG278HE monitor that worked fine under Windows 7, but now I'm using Windows 10, the highest refresh rate it supports is 60Hz. Asus doesn't have a driver on its website for Windows 10, and under the Device Manager, I see "Generic PnP Monitor." I talked with Asus, and it wasn't able to help. Naturally, I'd like to get my 144Hz setting back. After searching online, I found a couple of driver update programs, but I'm not sure if they are worth paying for.

If it helps, I'm using an Asus ROG Maximus VIII Hero Alpha, an Intel Core i7-6700K, an MSI GeForce GTX 1070, and 32GB of G.Skill DDR4 RAM. **–Craig M**

THE DOCTOR RESPONDS: Don't bother with a third-party driver update program. Simply head to www.nvidia.com, mouse over "Drivers," and click "GeForce Drivers." Choose the relevant options under "Manual Driver Search," and snag the latest build for Windows 10. Get it installed, right-click on your desktop, and select the "Nvidia Control Panel." Under "Change Resolution," you should have a drop-down for "Refresh Rate," and 144Hz should be available. If it isn't, double-check you're using a dual-link DVI cable between your graphics card and the monitor. None of the VG278HE's other display inputs support 144Hz operation.

Refresh Rate Madness

Hey Doc. To start, I am incredibly frustrated with Nvidia's hardware. Invariably, driver updates always result in a failure to install. I was dismayed that, when I replaced my GeForce GTX 970 with a GeForce GTX 1070 Sea Hawk, software on the bundled CD wouldn't even load. I ended up accepting a Windows Update version just to use the card. Is there a more reliable way of updating my drivers that doesn't involve hacking the Registry?

When I upgraded my video card, I also moved to a BenQ GW2075HT monitor. It is rated at 144Hz, but the best I can get from Windows is 70Hz. I am using the DisplayPort cable that came bundled with the display, and recently ordered a replacement in case this cable is defective. Do you have any other suggestions? **–Luis Kapel**

THE DOCTOR RESPONDS: It sounds like driver issues might be causing your monitor to not operate at its maximum refresh rate, Luis. Start by eradicating old driver files with DDU (Display Driver Uninstaller), available from www.wagnardsoft.com. Next, follow the guidance Craig M just received: Download the latest GeForce driver straight from Nvidia's website, open the Nvidia Control Panel, and check for a 144Hz option under "Change Resolution."

The Doc wishes he could be of more help. There is no mention of a GW2075HT on BenQ's website, and all of the company's 144Hz-capable PC displays currently listed belong to the XL series. With that said, double-check your monitor's model number and

↘ submit your questions to: doctor@maximumpc.com specifications to make certain it does indeed support 144Hz.

Picking an Upgrade

Dear Doctor, I am a retired veteran who loves to play PC games. I'm currently using an MSI Z87-GD65 Gaming motherboard with an Intel Core i7-4770 processor that's not overclocked. A GeForce GTX 780, 16GB of DDR3 memory, a 512GB SSD, and an outdated 1080p Acer monitor are all plugged in.

I am thinking of upgrading the monitor, graphics card, and memory. As of now, I'm leaning toward a GeForce GTX 1080, but I want to make sure my CPU won't bottleneck it. Next question: What's the best monitor for the money if I want to do 2K or better? Finally, what would be the best RAM upgrade? I have hit 100 percent too many times.

–Peter Walkoviak

THE DOCTOR RESPONDS: Thank you for your service, Peter. That MSI motherboard supports up to 32GB of memory, and if you're seeing 16GB gobbled up today, the only solution is installing four 8GB modules to max it out.

As for monitors, the GeForce GTX 1080 you're eyeballing calls for a resolution of at least 2560x1440. Anything lower would render the graphics card overkill. Although Nvidia's G-Sync adaptive refresh tech adds a hefty premium to any display, if you're willing to spend $500, Acer's 24-inch XB241YU is a nice complement to the GeForce. It may even be worth stepping down to a GeForce GTX 1070, if that's what it takes to free up extra cash for the best display possible.

The vanilla (non-K) Core i7-4770 operates at a base 3.4GHz, and Turbo Boost pushes it up to 3.9GHz in lightly threaded workloads. MSI's Z87-GD65 Gaming does include a BIOS feature called Enhanced Turbo. Enabling it sets all four of the i7-4770's cores to 3.9GHz, even under full utilization. Obviously, that won't buy you as much performance as a newer CPU or an aggressive overclock, but a Haswell-based chip at just under 4GHz should be fast enough to prevent bottlenecks in most games.

Thumb Drive Recovery

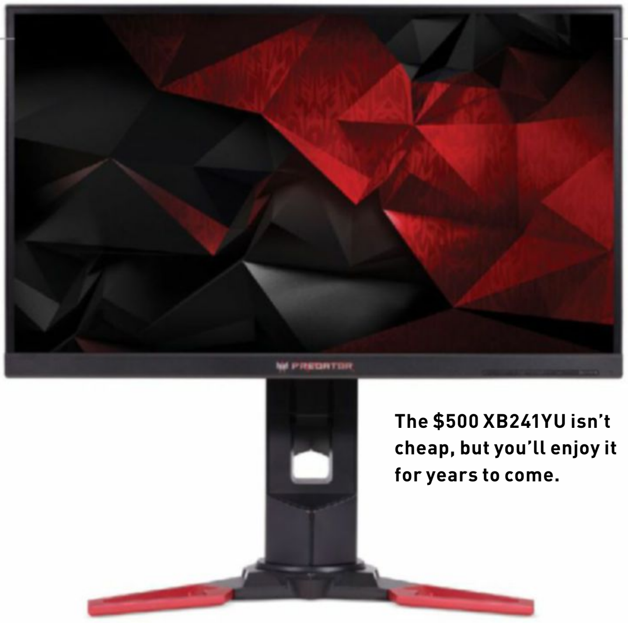
Hey Doc, I recently grabbed my favorite Corsair Flash Voyager GT to run a Linux partition again. I say again because I previously used it as an Ubuntu Installation Drive. Now, however, it appears useless. I've tried it in two PCs and with HP's USB Repair Tool. Whenever the drive is plugged into a USB port, it shows up in the Device Manager, Explorer, and Disk Management, but it can't be formatted, and double-clicking on it results in an error that says no disk is inserted. I can only rename the stick.

Corsair recommends sending it back, though that doesn't seem worth the trouble for a 16GB drive. Does it sound as though something might be corrupted, or is it unreadable because it was formatted by Linux?

–Ryan Pitts

THE DOCTOR RESPONDS: It's entirely possible that something is wrong with the drive. And the Doc agrees—when a 32GB Voyager GT sells for $25, there's not much reason to jump through hoops getting a 16GB model back to Corsair. But before you give up, dig a little deeper with Microsoft's DiskPart utility, which is built into Windows.

Start by plugging the drive in to a USB port. Under Windows 8 or 10, move your mouse to the bottom-left corner of your desktop, right-click, and select "Command Prompt (Admin)." Type "diskpart" in the window, then hit Enter. Using the command "list disk" returns similar information as the Management Console's Disk Management extension, but that should allow you to confirm your thumb drive's disk number. Next, type "select disk x," where "x" is the number corresponding to the Voyager GT. A message confirms the drive you picked. Double-check it's correct because the final command, "clean," removes all configuration information from the device, including its partition and data. If the drive is still good, you should be able to re-partition and format.



The $500 XB241YU isn't cheap, but you'll enjoy it for years to come.

Favorite Flight Sims

Greetings, Doc. I grew up on the Atari 800 and ST/TT systems. When Atari died, I went with Windows (I just couldn't stand the way Apple treated Digital Research and other Atari ST supporters). That was also the last time I even pretended to think I was a geek or knew what I was doing on a computer.

I fell in love with the many outstanding air combat simulators that prospered in the Windows 95 to Vista era. They made this old USAF veteran feel at home in P-51s, Me 262s, and more. But shortly after Windows Vista hit the market, they started vanishing. None of them were 64-bit-capable, and their developers didn't want to update them. All of my research suggests I shouldn't bother with any of them; compatibility just isn't there. The few success stories I've read were loaded with cumbersome Registry hacks and other workarounds I dare not try.

Please, are there any good Windows 7- and 10-compatible WWII sims you might consider plug-and-play? I did 20 years in Air Force blue. My father flew over Nazi-occupied Germany in B-17s and -24s. It breaks my heart that I can't fly those skies and pretend he's out there with me somewhere.

I just finished building a new machine with an Intel Core i7-6850K, an EVGA GeForce GTX 1080, 64GB of memory, a 1TB SSD, and, of course, Windows 10 Home.

–Gregg Anderson

THE DOCTOR RESPONDS: Although the Doc never got into flight sims, he has friends with projector-based wraparound displays and custom-built cockpits. The consensus seems to be that *IL-2 Sturmovik: 1946* remains one of the most popular sims out there, despite the fact it's a decade old.

According to the product page for *IL-2* on GOG.com, Windows 7 and 10 are both compatible (though some folks report needing to launch it in Windows XP compatibility mode). The simulator does cost $10, but you also get a 30-day money-back guarantee through the CD Projekt-owned distribution platform, should it prove too complicated to set up.

Be sure you visit http://forum.1cpublishing.eu after installing, and click on the *IL-2 Sturmovik* community. Inside, you'll find a number of sticky posts, including one that walks you through applying a long series of patches. Each patch is accompanied by a changelog detailing new content and bug fixes. The Doc is assured a lot of work goes into keeping that title fresh, so give it a shot.

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SUPER SILENT SYSTEM

A brave venture into fanless PCs and minimal noise

By Zak Storey

We have questions. Questions that need answering. OK, maybe not quite on the same level as Gandalf needing to know whether a certain golden trinket belonging to Bilbo Baggins was wielded by the dark lord Sauron, but we think they're just as valid. After all, isn't the advancement of technology and silent computing just an extended metaphorical allegory of that servant of Morgoth's rise to power?

Too much? OK, back to something a little more rational. The questions of which we're speaking are: Is it possible to build an almost fanless PC? One that has little, if any, capacity to generate noise? It's a concept we've mused over ever since we crafted our Dream Machine in 2016. The Core i7-6950X located at the heart of our $10,000 build was cooled by a single (admittedly rather chunky) 240mm radiator. Though, of course, it was surrounded by a plethora of other fans, in a somewhat open-aired chassis.... Combine that with our experience of benchmark testing, when we use little in the way of cooling on our open-air test bed, and you can see where these thoughts first arose.

The theory was simple, then: Take a high-end system—Core i7-6950X, 64GB of DDR4, and a Fury X—and combine that with soft-tube liquid cooling, including two 360mm radiators (one extra-thick, and another still twice as thick as any AIO), and then add one of Corsair's AX1200i power supplies, because the fan itself never spins under 50 percent load. If it works, fabulous. If not, then we can add fans at a later date to soothe this monster's fevered wrath.

On top of that, there's a few extra cautions we decided to include, just in case. From the get-go, we'd be using Be Quiet!'s phenomenally modular Dark Base Pro 900 chassis. Its additional soundproofing and expansive liquid-cooling support are exceptional, and having the opportunity to mount fans stealthily at a later date meant we could truly take advantage of the interior space. And, of course, speaking of additional backup cooling, in case our theory fell through, we decided to test out another of Be Quiet!'s latest products: the Silent Wings 3 120mm high-speed fans. Specifically designed with radiators and static pressure in mind, these pressure pushers pump out an impressive 3.37mmH_2O at full speed, topping out at 28.6dBA, and come in a sleek black finish, too. Compare that with Corsair's legendary SP120 series high-pressure fan at 3.1mmH_2O and 35dBA, and you can see why we were intrigued by them. So, on to the build itself!

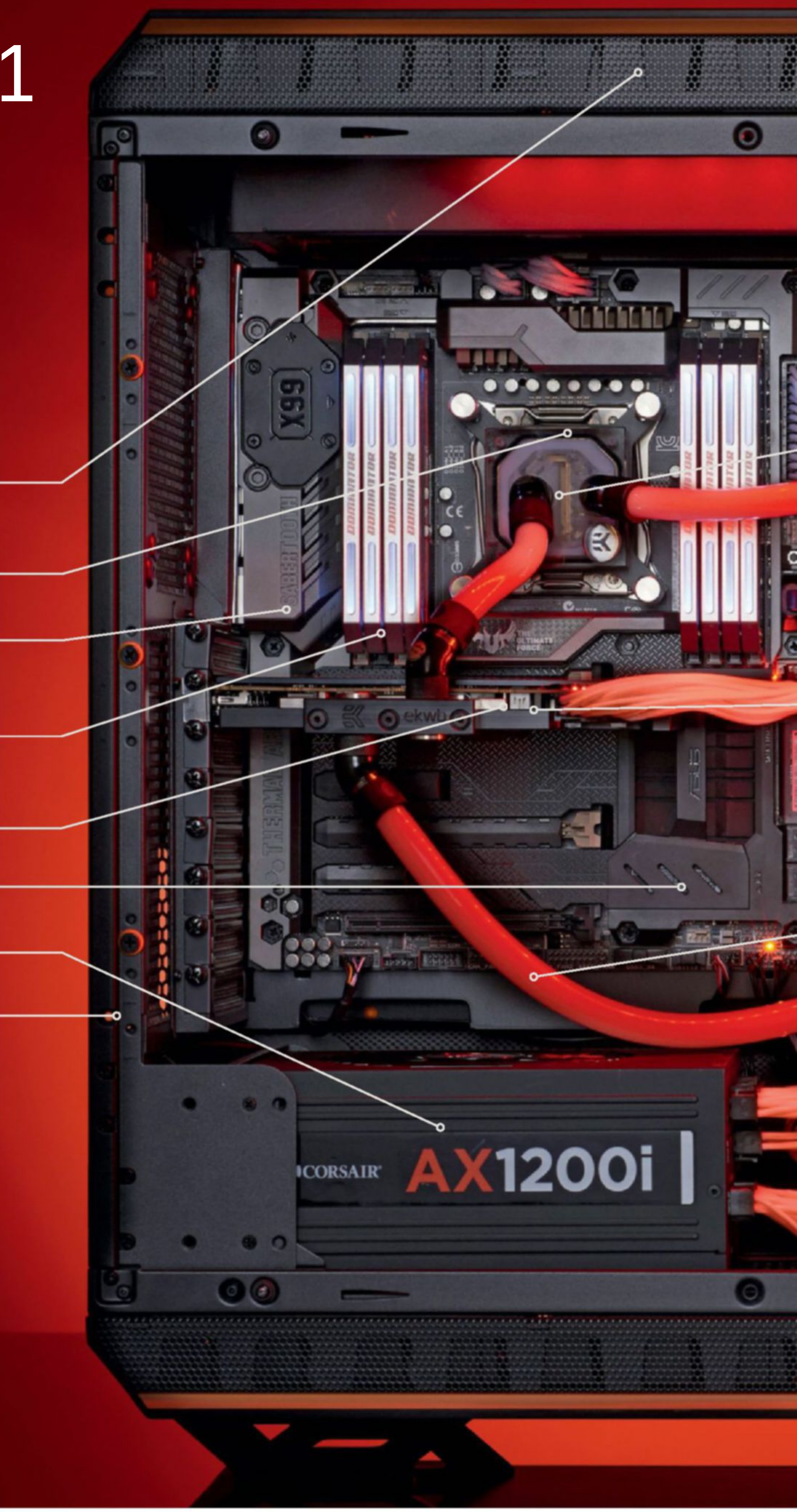
AX1200i
CORSAIR
DDC X-Res
be quiet!

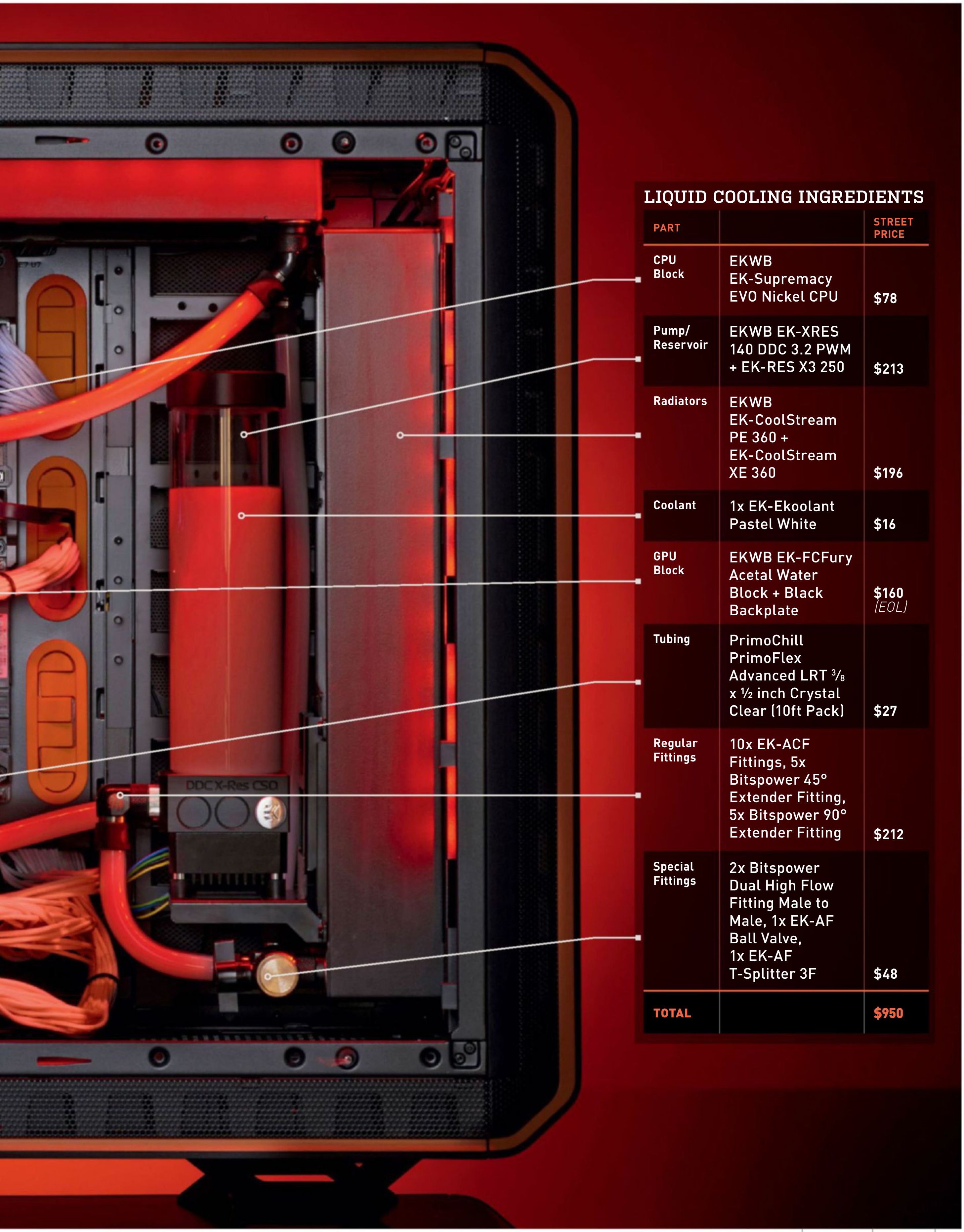
Silence is golden.
And liquid-cooled.

THE $5,701 SILENT SYSTEM

HARDWARE INGREDIENTS

PART		STREET PRICE
Fans	6x Be Quiet! 120mm Silent Wings 3 High-Speed Fans	$114
CPU	Intel Core i7-6950X @ 4GHz	$1,579
Mobo	Asus X99 TUF Sabertooth	$295
Memory	64GB (8x 8GB) Corsair Dominator Platinum 2,400MT/s	$480
GPU	Asus R9 Fury X	$459
SSD	2TB Samsung 960 Pro M.2 PCIe SSD	$1,298
PSU	Corsair AX1200i Platinum	$311
Case	Be Quiet! Dark Base Pro 900	$215
TOTAL		**$4,751**





LIQUID COOLING INGREDIENTS

PART		STREET PRICE
CPU Block	EKWB EK-Supremacy EVO Nickel CPU	$78
Pump/ Reservoir	EKWB EK-XRES 140 DDC 3.2 PWM + EK-RES X3 250	$213
Radiators	EKWB EK-CoolStream PE 360 + EK-CoolStream XE 360	$196
Coolant	1x EK-Ekoolant Pastel White	$16
GPU Block	EKWB EK-FCFury Acetal Water Block + Black Backplate	$160 (EOL)
Tubing	PrimoChill PrimoFlex Advanced LRT 3/8 x ½ inch Crystal Clear (10ft Pack)	$27
Regular Fittings	10x EK-ACF Fittings, 5x Bitspower 45° Extender Fitting, 5x Bitspower 90° Extender Fitting	$212
Special Fittings	2x Bitspower Dual High Flow Fitting Male to Male, 1x EK-AF Ball Valve, 1x EK-AF T-Splitter 3F	$48
TOTAL		**$950**

PRECISION COOLING PROCEDURE

BEGINNING ANY LIQUID-COOLED BUILD is always daunting. Mixing liquid with electricity goes against everything we've been taught, but there's no denying that it's by far the most efficient method of chilling beefy components. Right from the start, you need to plan carefully. You must establish exactly how many fittings you need, what components you have to cool, how you're going to have your loop set up, and, of course, where you are going run your tubing. We're going to take you through a step-by-step guide to how we put this particular build together, and hopefully inspire you to try it out yourself.

1

STRIP THE CASE

AFTER YOU'VE SELECTED an adequate case, gathered your hardware, and made sure that the case itself supports the cooling you have in mind, the first thing you should do is strip the case of any unwanted hardware. Be Quiet!'s Dark Base Pro 900 was particularly in need of stripping down. There's a plethora of hard drive bays located in the front of the case, and a 5.25-inch bay to contend with, too, all of which needed removing to allow room for our two radiators, pump, and considerable amount of hardware. Once removed, hold on to them, in case you do swap out your system at some later point. Right now, you should remove all the panels you can, including the roof, front, any dust filters, and side panels. Carefully place these in the box the chassis came in, preferably between the hard-foam packaging, to ensure they don't get damaged.

You should also remove any unnecessary cables, and find a way of tucking the front I/O cables out of the way—either tie them somewhere neat in the back with the included stock wire cable ties, or just tuck them out of the way until you need them later.

The reason we're stripping the case down to its bare bones is that it makes life so much easier when it comes to the build process itself. You may notice from our photography that we haven't taken all the panels off our case—this is purely for show, and to make the feature look a little more interesting than if we were working in completely stripped-down chassis.

2

TRY A TEST FITTING

YOU CAN DO ALL THE THEORIZING and planning in the world, but you won't know what you have to work with until you have all the hardware. This is one of the biggest risks of water cooling, and often where you'll find you need to purchase more kit. Even at *Maximum PC*, it takes us two or three orders each time we build a liquid-cooled system to get all the parts we need.

We suggest you install your motherboard in the system, without anything attached. Then place your power supply in as well (not necessarily screwed down), and take a look at where your radiators will go.

This should give you time to line up your fittings, visualize your tubing runs, and alert you to any potential issues. For us, it was during this phase that we identified that we couldn't install EKWB's XE 360mm in the roof, because clearance for the motherboard was a major issue, so we decided to place the thicker XE at the front instead, and use the skinnier PE 360 in the roof. Although still a little tight when it came to installing the two EPS power cables we needed at the top of the X99 TUF, we could slide them in ahead of installing the mobo to resolve the issue, then install the radiator after that to solve the problem .

LC Solution CoolStream XE

3

INSTALL THE KEY COMPONENTS

YOU SHOULD INSTALL the two chunkier components first: the motherboard and the power supply. The good thing about a modular PSU is that it's just a box with nothing attached, until you need it to be. In a chassis with a power supply cover, such as Phanteks' Evolv or NZXT's Manta, you can leave this until later; it's only when you might need to run tubing across the PSU that you must install it first.

You can see in our build that the fan is facing up. This is for two reasons. Firstly, so we can make sure that the fan isn't spinning while the system is under load, and secondly because it looks more interesting. That said, this PSU has been witness to a nasty water-cooling leak in the past, with a fitting on a Fury X giving way after it was knocked too many times. Because the power supply fan was facing down in that instance, no coolant entered the system, and the power supply survived.

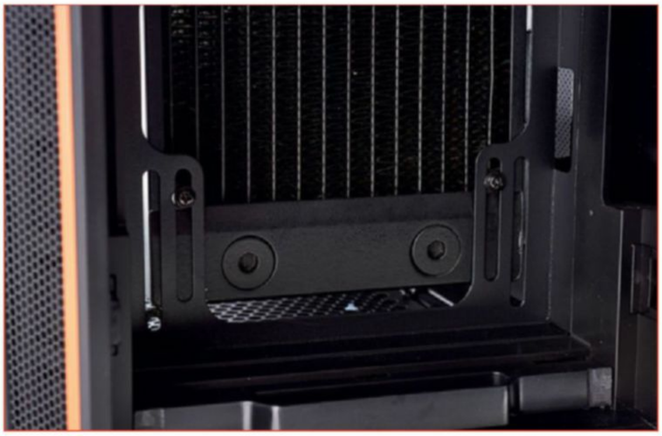
CORSAIR
AX1200i

4

ADD THE RADIATORS

THERE'S A FEW WAYS to install radiators—it depends on how patient you are, and what size radiators you're fitting. The larger triple-fan behemoths require a little extra care. You can install the radiator to the panel, with a fan on the exterior, using long mounting screws, pinning the two with the case panel in the middle (on cases that support it). Or precariously mount the fans and the radiators on the inside of the chassis by threading those same long screws through the case panel, through the fan, and into the radiator. Or you can mount the radiator to the case on the inside, using every other screw, then mount the fans on the outside of the case panel using the remaining screw holes. That is if you want to have your fans set up in a push configuration.

You also need to keep in mind where your G1/4-inch mounting points are on your radiators, and ensure you've got enough space to run your cables and fittings through.



5

FIT THE PUMP

NEXT UP IS YOUR PUMP and reservoir. We recommend saving space and grabbing a combi pump/res, as it's a lot less hassle. Manufacturers make a plethora of different sized pumps, but the smaller the pump, the higher the whine, due to a smaller sized fan running at higher RPMs.

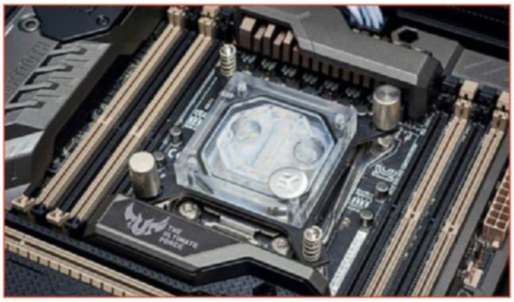
Pictured is EKWB's EK-XRES 100 DDC 3.2 PWM Elite, with an XRES-250 reservoir. Some cases support reservoir or pump mounting, while others are less forgiving—in such a case, you can invest in a mounting bracket, as we did. The bracket is secured to the radiator, then you secure the pump to the bracket. If you intend to use the recessed G1/4-inch fitting on the pump/res combi, you need to use the included extender fitting, and if you intend to use a tubing run on the top of the res, you need to invest in a down tube as well. We suggest you use the in and out ports on the bottom of the pump, and use the top of the res as a fill port.

6

INSTALL YOUR CPU BLOCK

FOR A 2011 SOCKET, once your CPU is locked in place with a dab of thermal paste, install the included 2011 socket mounting screws, place the block on top, add the included spring to each stand-off, then screw it down using the included silver caps. Always secure these in a star configuration (bottom-left first, then top-right, then the other two points), to ensure you don't damage the CPU by placing too much weight on one side.

For more mainstream CPUs, you have to do this prior to installing the mobo, as you need to attach a backplate to the board, thread the stand-off screws through it, attach the block, and secure it in the same way. There's no wrong orientation to mount the block, but you want the coolest liquid flowing in the inlet, and out the outlet.

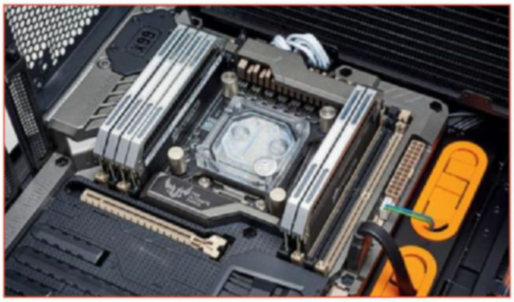


7

ADD SOME RAM

YOU'VE GOT YOUR RADIATORS IN, and your power supply and motherboard are installed, so it's time to install the "smaller" components. RAM is first on the list. As you can see, we've also sneakily plugged in a few front panel headers now, plus the pump fan header, and have threaded the EPS power in, too, before getting too involved with the water cooling.

We decided to use eight sticks of 8GB Corsair Dominator Platinums, so which slots to place these in wasn't a big deal. However, if you're using a kit of four, you must ensure you install the DDR4 into the correct matching channels. Fortunately, on most X99 boards, these are color-coded, and it's also obvious on any Z270 or AM4 boards, because there are only four slots.

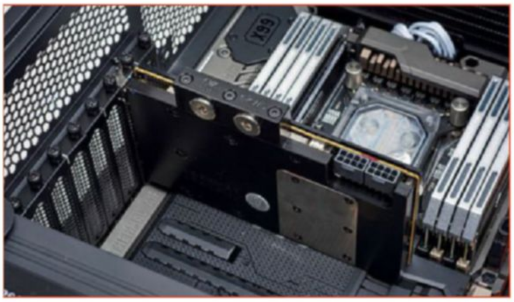


8

FIT THE GPU

YOU PROBABLY KNOW how to install a GPU—make sure it's lined up with the slot, the PCIe covers have been removed from the rear of the chassis, then gently slot it in. The biggy is the GPU block—the tricky part comes from removing the stock cooler. Work from the backplate first. Take a picture first for reference, then remove each screw, and keep them safe for future use. Work your way around to the rear I/O of the card, and remove the screws. Gently remove the fan cables on the PCB, then you should be able to pull the stock cooler off.

Remove the thermal paste from the GPU (the silver square), and any thermal pads (gray spongy strips) from the memory stacks and VRMs. Then follow the manufacturer's instructions to mount your waterblock.

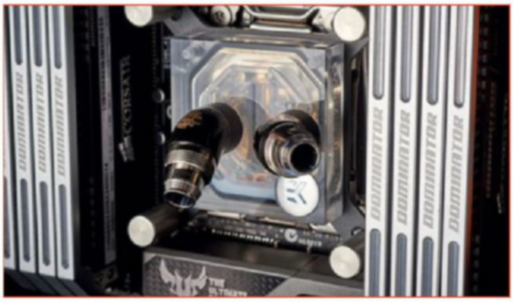


9

UNDERSTAND THE FITTINGS

FITTINGS ARE ONE OF THE BIGGEST expenses in a water-cooled system. Always buy two or three more than you think you need, and get some rotating 45- and 90-degree fittings to help move things along. You also need the correct type of fitting for your tubing. For hard tubing, there are fittings with two rubber o-rings; for soft tubing, compression fittings are your best bet.

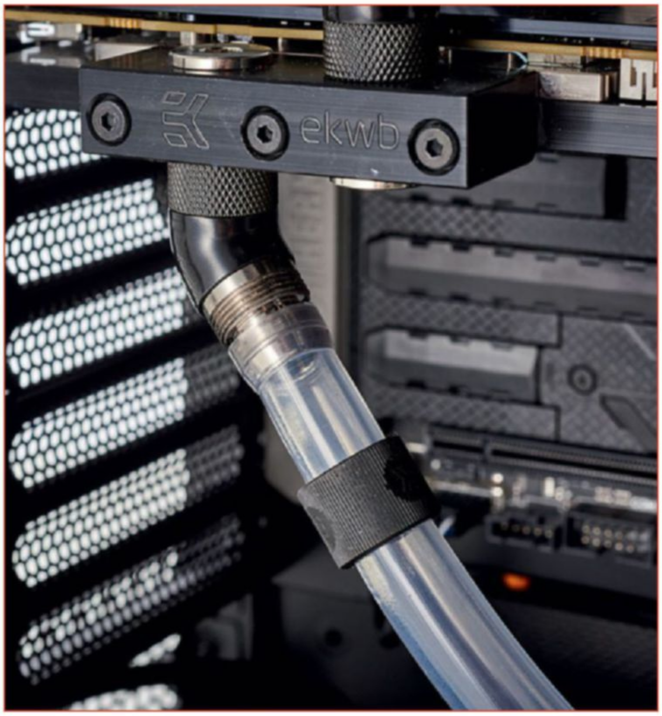
Look at the easiest routes from A to B. You're trying to avoid unnecessary kinks in tubing runs, so use a combination of angled and straight fittings. Use plugs to block off unused ports on the reservoirs and graphics cards. And place a drain port at the lowest point—it makes life easier if you need to drain your system. Use a T splitter block and ball valve, and you're all set.



10 INSERT THE TUBING

WHEN IT COMES TO SOFT TUBING and hard piping, both have their merits, and both have their frustrations. Getting the bends just right on a piece of acrylic takes time to master, and can lead to many failed attempts. However, it's also by far the easier of the two types to install and fix. Soft tubing, on the other hand, is easier to cut and line up, but a nightmare to install. In short, for soft tubing, get a length of tubing (make sure you purchase the correct outer and inner diameter of tube for the fittings you have), line it up between the two points, and cut off slightly more than you think you need. A pair of large, sharp scissors will do the trick, although you can buy tools specifically designed for soft tubing.

Next, you need to take a set of needlenose pliers, insert them in the end of the tube you're attaching to the fitting, then stretch it outward. Do this in two different directions to give you a bit of slack to play with. Then install your fitting cap over the tube, and try to wiggle it over the barb on the compression fitting. Push it down until the tube is all the way up to the thread, then move the second part of the fitting up, and screw it into place. This compresses the tube and locks it into place. Repeat across your entire system, and you're good to go.



11 SORT OUT THE CABLING

WE'RE FINALLY STARTING to wrap up the system. For our build, we've already threaded the EPS power through, to allow for that tight mobo/top rad combo, so now it's all about working the remaining cables around the back of the chassis, and into their allocated positions. Work around the tubing where you can. Unfortunately, in the Dark Base 900 Pro, there is no PSU cover, so we're going to go straight out the back with all the cables, bundle up the ones we don't need, where we can, and tie them down to the chassis with a combination of cable ties and plastic-coated wire. It doesn't need to look super-glamorous back there.

There are a few things you can do to enhance the appearance of your cabling. Cable combs, for instance, are a great addition to ensure your cabling looks clean and sharp, and most places that sell custom cable kits probably also have cable combs available, so bear that in mind when you're building your system. With a modular PSU, everything else should be pretty straightforward.

DOMINATOR
CORSAIR

12

FILL THE LOOP

NOW COMES THE FUN PART: filling the loop. But first, take precautions—paper towels are your best friend, so grab as many as you can, and place them around the system, above and below all your major fittings.

If you've followed us so far, you simply need to unplug the fitting at the top of your reservoir, attach a length of tubing with a fitting, then, either using a funnel or a squirty plastic sauce bottle, pour the coolant into the reservoir. It goes without saying that your entire system should be switched off at this point. You should be looking at adding coolant until the reservoir is around 70 percent full.

We're a big fan of EKWB's pastel coolant concentrate. It contains all the biocides and anti-corrosion inhibitors you need, and is easy to mix. Simply add one part concentrate to two parts tap water (or deionized water, if you really want to be jazzy), and you're set.

13

CYCLE THE LOOP

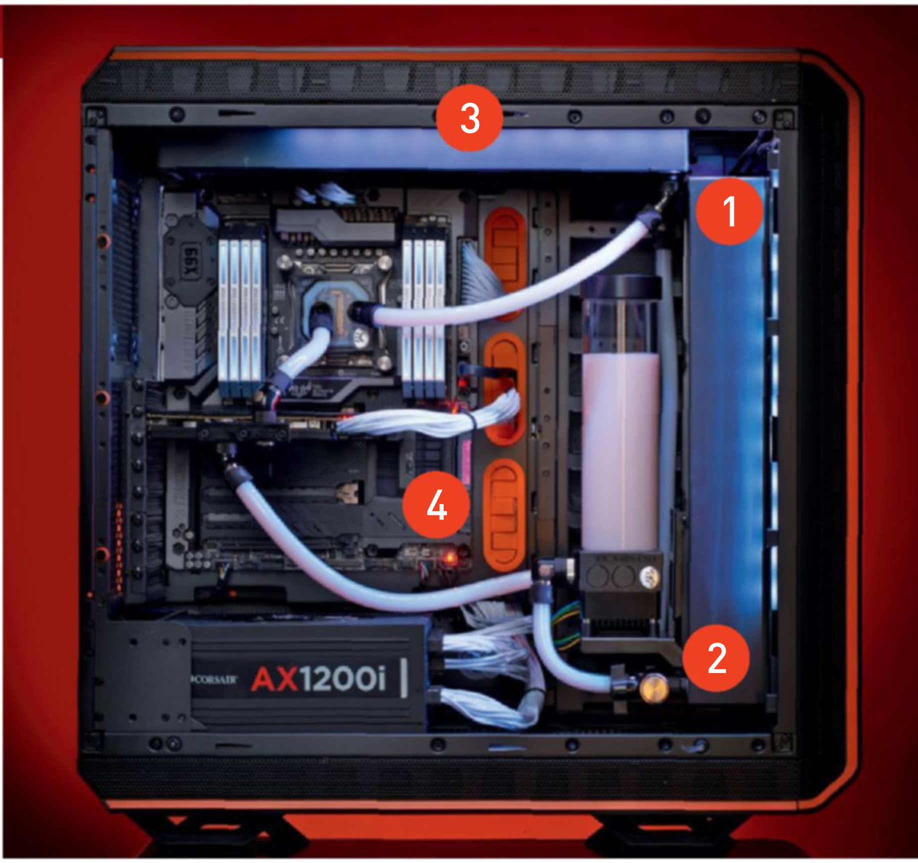
FIRST, PREP YOUR POWER SUPPLY. Remove the PCIe power from your GPU, unplug your EPS power from the mobo, then unplug your 24-pin ATX power. Keep your pump plugged into its Molex power, but unplug the pump fan header. Make sure your PSU is off and unplugged. Now, you can either buy a 24-pin ATX bridge from Newegg for $10 (XSPC ATX PSU Bridge Tool), or bridge the PSU yourself—use a paper clip or piece of plastic-coated copper wire, strip the plastic off each end, and with the retention clip of the 24-pin ATX cable facing down, bridge the fourth and fifth pins from the right, on the bottom row of pinouts. During the next step, do not touch the wire. Plug your PC in, and switch on the PSU. Run the system for a few seconds as the pump cycles the coolant around. Don't let the pump run dry, as you'll damage the bearing. Refill the res, and cycle the pump until you have a continuously flowing liquid-cooled system.

14

TEST FOR LEAKS

AND VOILA! You now have a fully running liquid-cooled loop. We suggest you run it like this for at least 24 hours, to make doubly sure there's no leaks, using the paper towels as indicators. Once this is all wrapped up, you can plug all of your hardware back in, and get to testing and installing your operating system. Overall temperatures should be far lower than any AIO can muster—especially under load—and the absence of fans on your graphics card ensures a super-silent system.

What you're left with is, in our opinion, a masterpiece. Are water-cooled machines easy to build? There are a few extra steps involved, but if you take your time, plan it well, double-check everything, and do your research ahead of time, you shouldn't go wrong. Arguably, it's the mistakes we make that teach us the most, but when you're messing around with $1,500 processors, they're something you generally want to avoid.



1 Not that you can see it here, but the tubing that runs from the top radiator to the front radiator utilizes four separate 90-degree fittings to line up just right, just behind the pump/res.

2 This length of tubing running from the front radiator to the pump/reservoir combo's inlet port also serves as a drain valve, using a ball valve fitting, two male to male connectors, and a T splitter.

3 Located along the front and top of the case, the two adhesive RGB LED strips allow us to change the white coolant to any color we like, with just a quick click of a front-panel button.

4 There's no other backup hard drives located anywhere in this build, but the 2TB Samsung 960 Pro hidden under the motherboard's armor packs enough wallop for us.

CONCLUSION

DID OUR VENTURE into a quick and easy fanless system work? Sort of. Idling and on desktop, the system can go all day without a flutter. However, during benchmarking, we encountered issues. After 52 minutes of testing, the processor reached its Tj max of 100 C, and, boy, were those radiators hot. For short bursts, the benchmarking process was fine, but if you intend to render for any length of time (beyond 20–30 minutes, at 4GHz), issues would soon become apparent.

That said, the processor didn't throttle under load, and remained at 4GHz turbo. When we added Be Quiet!'s Silent Wings fans to the interior radiators, temperatures dropped dramatically, and remained stable at around 55 C throughout our benchmarks, even while running under lower RPMs. This suggests that airflow is the important factor. We still managed to keep the system excruciatingly quiet, with the fans registering less than 9.8dBA at 33 percent speed. Ramping that up to 66 or 100 percent via the TUF X99's onboard fan controller improved temperatures by up to 8 C, but it did increase noise levels notably.

We also decided to see what would happen if we swapped from a fully positive airflow system to a more balanced system, with the three fans at the front on the XE360 drawing air into the case, and the three on the PE in the roof exhausting instead. Overall, we didn't see any massive temperature difference, with most results being well within the margin of error.

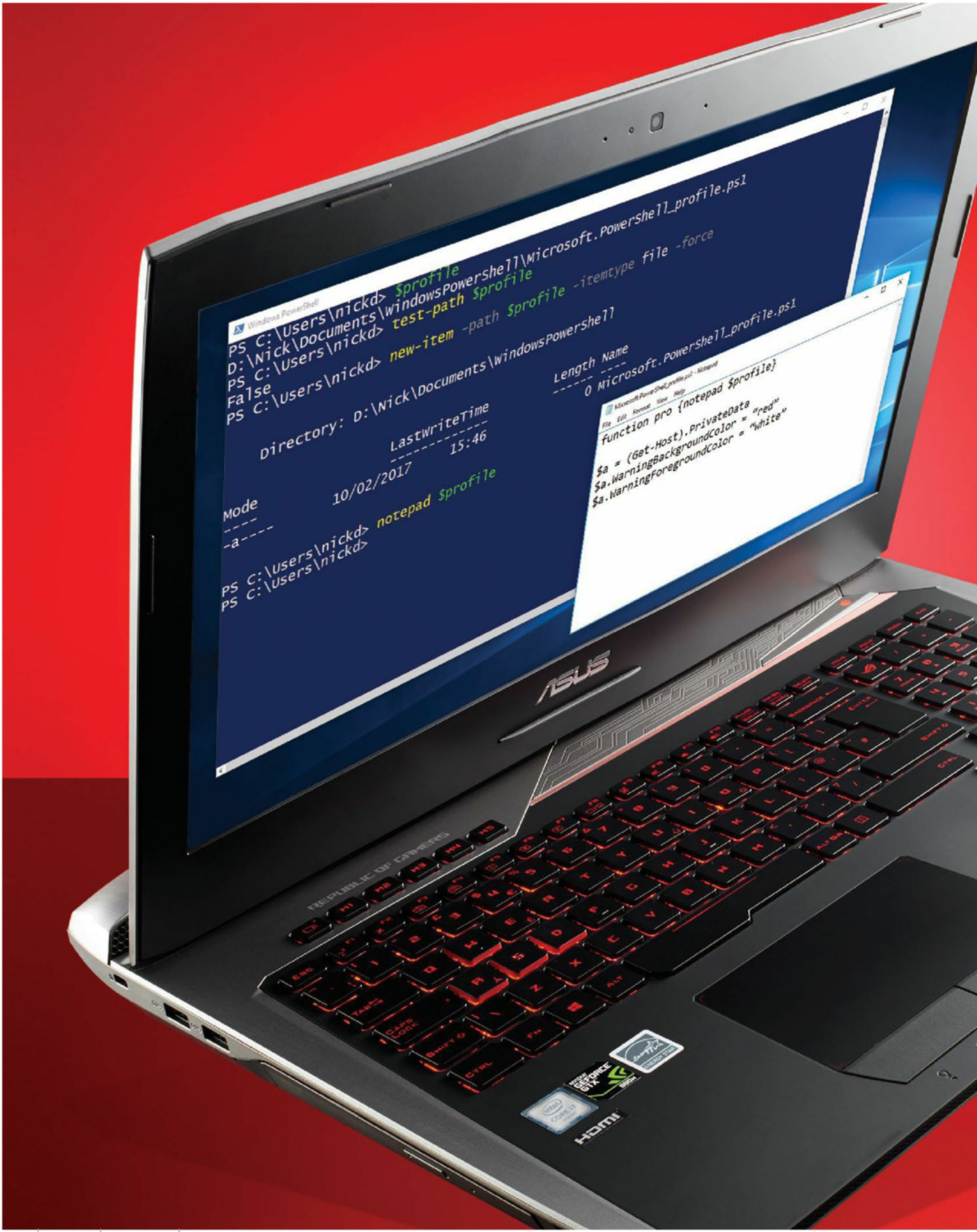
Using soft tubing was a godsend—it's easy to manipulate, and with enough angled fittings, generally isn't an issue. It's worth mentioning just how vital those fittings are: We did a similar feature way back in 2015, utilizing a Core i7-5820K and the Fractal Define S chassis, but routing the soft tubing was a nightmare compared to this build, even making the hard tubing NZXT Manta easy in stark contrast.

So, to answer the question, can a high-end, silent, passive rendering workstation be achieved? Sadly, at this moment in time, we don't believe so. That said, with a little thought and some neat cooling, you can optimize a system to be near-silent, and that's close enough in our eyes.

BENCHMARKS

	0% Fan Speed	33% Fan Speed	66% Fan Speed	100% Fan Speed
Prime 95: Positive	57 C	54 C	49 C	46 C
Prime 95: Balanced	57 C	53 C	48 C	45 C
Fire Strike Loop: Positive	68 C	52 C	44 C	40 C
Fire Strike Loop: Balanced	68 C	54 C	43 C	40 C
Average Recorded RPM	0	773	1,472	2,073
Theoretical Fan dBA	0	9.4	18.9	28.6

All benchmarks performed for 10 minutes, at respective fan speeds, with 10-minute cooldown at 100 percent fan speed. Temperatures are highest recorded for CPU and GPU over 10-minute benchmark; RPM is the mean over five minutes.



Windows PowerShell
Microsoft.PowerShell_profile.ps1 - Notepad
File Edit Format View Help
ASUS
REPUBLIC OF GAMERS

```
PS C:\Users\nickd> $profile
D:\Nick\Documents\WindowsPowerShell\Microsoft.PowerShell_profile.ps1
PS C:\Users\nickd> test-path $profile
False
PS C:\Users\nickd> new-item -path $profile -itemtype file -force

    Directory: D:\Nick\Documents\WindowsPowerShell

Mode                LastWriteTime         Length Name
----                -------------         ------ ----
-a----       10/02/2017     15:46              0 Microsoft.PowerShell_profile.ps1

PS C:\Users\nickd> notepad $profile
PS C:\Users\nickd>
```

```
function pro {notepad $profile}

$a = (Get-Host).PrivateData
$a.WarningBackgroundColor = "red"
$a.WarningForegroundColor = "white"
```

MASTER THE POWERSHELL

Discover how to get started with Microsoft's powerful scripting tool, with *Nick Peers*

At first glance, the Windows PowerShell looks to be a facsimile of the Command Prompt, but to dismiss it as such leaves you missing a huge trick. In fact, PowerShell is a platform designed to automate many Windows tasks through a clever scripting language. It's based on the .NET Framework, which gives it lots of flexibility and scope, particularly when you access it through the PowerShell ISE (Integrated Scripting Environment) program, which provides even more useful tools and shortcuts—such as syntax highlighting and IntelliSense tab completion—to help you build the perfect script to achieve what you want.

If you've already dabbled with the Command Prompt—and .bat batch files in particular—you're already well on the road to getting to grips with PowerShell. Many familiar commands work in PowerShell, too—thanks to a clever aliasing system, you can type a Command Prompt command and it's automatically translated into the correct PowerShell command.

In this article, we're going to introduce you to the PowerShell from the perspective of someone who's not encountered it before, and is interested in discovering what it may or may not be able to do for them. We'll make some fairly basic assumptions—you're aware of how programing and scripting work, for example—but we will start at the beginning, teaching you the fundamental building blocks of PowerShell. In the process, we'll reveal what "cmdlets" are and how they work, plus you'll discover how to stitch them together to form fully functional commands, gently easing you into the world of scripting. We'll also introduce the basic syntax and structure of the language, while providing you with some real-world examples to try.

You'll find out how to install the latest version of PowerShell in older versions of Windows, discover how to get help, and find some of the best online reference guides. You'll also learn about setting up profiles, and gain useful tips and tricks to help you start to use PowerShell to make your own computing life that bit more easy. Ready to start on the road to becoming a PowerShell guru? Let's go!

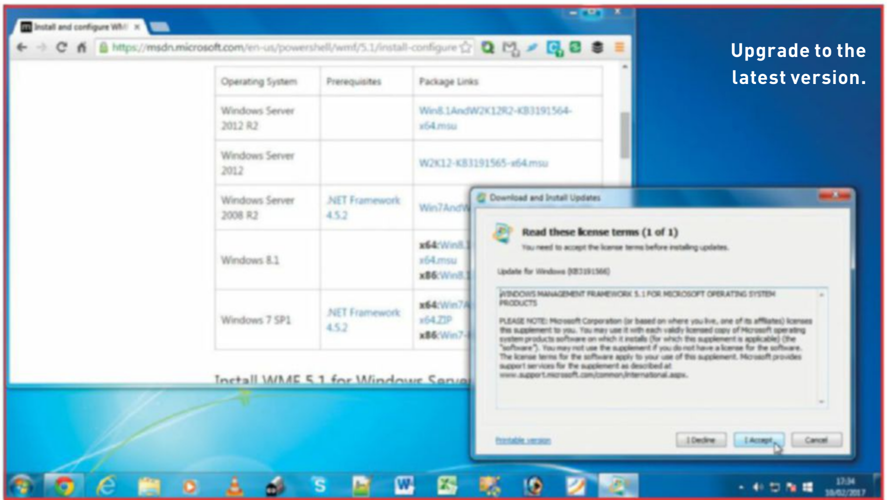
We'll begin by opening PowerShell—if you're running Windows 7, 8, or 8.1, check the box over the page to obtain the latest version. Click the "Start" button, and scroll down the "All Apps" list until you locate the "Windows PowerShell" folder. Click this to reveal two (or four if you're running 64-bit Windows) options: "PowerShell" and "PowerShell ISE." Let's start with the basic PowerShell command prompt, so select

"PowerShell." This launches the application with non-administrative privileges, and places you in your own personal user folder, just like the Command Prompt. Right-click the shortcut, and choose "Run as Administrator," and it places you at C:\Windows\System32. It goes without saying, though, that you shouldn't run PowerShell as an administrator unless you specifically need to. For the purposes of this tutorial, we're going to stick to running it as a regular user, except where stated.

The PowerShell window opens, providing you with a similar—at first glance—interface to the regular Command Prompt. You can customize the view by right-clicking its menu bar and choosing "Properties" to reveal a tabbed window. The options are broadly identical to the Command Prompt—use the "Font," "Layout," and "Colors" tabs to customize its look and feel.

To help you plot a route through potentially maze-like commands, the text changes color as you type different parts of the command: cmdlets and aliases are yellow, with parameters displayed in white, and flags (switches preceded by the – (dash) symbol) in gray. Variables are displayed in green, and text strings in dark blue.

As an aside, you can change these—and other message colors—if you don't like them, but those options are edited using PowerShell commands. We'll look at them in more detail later on.


Install and configure WMF
https://msdn.microsoft.com/en-us/powershell/wmf/5.1/install-configure

Operating System	Prerequisites	Package Links
Windows Server 2012 R2		Win8.1AndW2K12R2-KB3191564-x64.msu
Windows Server 2012		W2K12-KB3191565-x64.msu
Windows Server 2008 R2	.NET Framework 4.5.2	Win7AndW
Windows 8.1		**x64:** Win8.1 x64.msu **x86:** Win8.1
Windows 7 SP1	.NET Framework 4.5.2	**x64:** Win7A x64.ZIP **x86:** Win7-

Install WMF 5.1 for Windows Serv

Download and Install Updates

Read these license terms (1 of 1)

You need to accept the license terms before installing updates.

Update for Windows (KB3191566)

WINDOWS MANAGEMENT FRAMEWORK 5.1 FOR MICROSOFT OPERATING SYSTEM PRODUCTS

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Upgrade to the latest version.

GET POWERSHELL

We're featuring the most recent release of PowerShell—version 5.1—and it comes pre-installed with the latest version of Windows 10. All you need to do is launch it, either from the Start menu's "All Apps" list, or by typing "powershell" into the "Search" box. You can then right-click its Taskbar icon and choose "Pin to Taskbar" for a convenient shortcut going forward.

Windows 8 and 8.1 users currently use PowerShell 4. If you want to upgrade to version 5.1, simply download the correct version—x86 (32-bit) or x64 (64-bit)—from https://msdn.microsoft.com/en-us/powershell/wmf/5.1/install-configure. Double-click it, and follow the installation prompts.

Windows 7 ships with an even older version of PowerShell, dating back to 2009. To upgrade that, you first need to verify the .NET Framework 4.5.2 is installed (a link to it is provided at the site above, or you can install it through Windows Update). Once done, download the relevant x86 or x64 standalone installer file (around 65MB), then double-click it, and again follow the prompts.

Once installed, you're prompted to reboot, so do so, and impatiently wait for Windows to reload. Then it's a case of simply opening PowerShell in the usual way—via the "Start" menu or by pressing Win-Q in Windows 8 to open the Search charm. The latest version powers up (you can verify this by checking out the copyright notice, which should now read "2016," rather than "2009" or "2012"), and you're ready to delve into PowerShell without missing out on all the latest improvements and new features.

To see what's new, click "New Scenarios and Features" on the download page for version 5.1, and also check out the "WMF 5.0" link, where you'll discover major features introduced since Windows 7 and 8 were released.

FIRST STEPS

PowerShell is about building blocks. Those blocks are known as "cmdlets." They're called this to differentiate them from commands as used by the Command Prompt. In the Command Prompt, commands either refer to specific programs, such as chkdsk.exe or edit.com, or are "internal commands" related to the main command.com program (for example, "dir" and "mkdir").

Cmdlets work in a different way. PowerShell works through the .NET Framework, so cmdlets are actually instances of .NET Framework classes, not standalone executable files. What this means in practice is that cmdlets rely on PowerShell to handle the parsing of commands, plus provide any error presentation and output formatting.

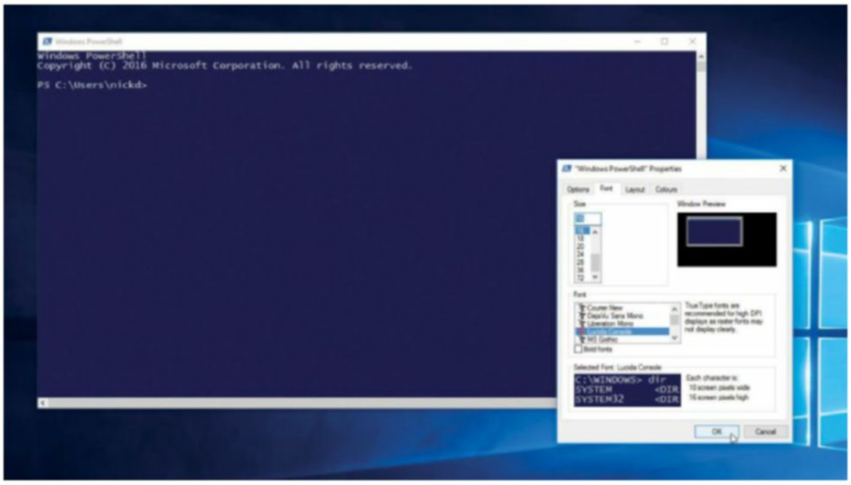
Furthermore, while commands are designed to work on their own, cmdlets can work in isolation, or be used in combination with others to create more feature-complete commands. Cmdlets can be split into various types, enabling you to mix and match with precision to get the results you need. Indeed, with some practice, you'll be able to build complete applications from just a few dozen lines of code.

CMDLETS UNCOVERED

All cmdlets follow the same structure: verb-noun. So you have "Get-Alias," "Clear-History," "Set-Location," and so on, which helps make them easier to grasp. The verb part of the cmdlet reveals what it's designed to do—for example, "Get" cmdlets are designed to retrieve data, while "Set" cmdlets are used to establish or change data. "Format" cmdlets format data in a particular way, and "Out" cmdlets are designed to direct your command's output to a specific destination, whether that's the screen, a file, or somewhere else.

Many cmdlets have abbreviated aliases, too. These are shortened forms of the cmdlet—for example, "clhy" refers to "Clear-History," the command for deleting all entries from the command history. Others link back to the Command Prompt, to make it easier for those with experience of the command line to migrate across to PowerShell. For example, "cd" refers to "Set-Location," which is used to change the working directory in PowerShell, while "dir" is the alias for "Get-ChildItem," which is used to list the files and folders in the

You'll be able to build complete applications from just a few dozen lines of code.



```
Windows PowerShell
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PS C:\Users\nickd>
```

Selected Font: Lucida Console

```
C:\WINDOWS> dir
SYSTEM      <DIR
SYSTEM32    <DIR
```

Each character is:
10 screen pixels wide
16 screen pixels high

You can tweak the appearance of the PowerShell interface from here.

current directory. To list all aliases, use the "Get-Alias" cmdlet on its own, like so:

```
> Get-Alias
```

Add "alias" to the end, substituting "alias" with your chosen alias, to get a specific command. For example:

```
> Get-Alias dir
```

To find out more about what specific cmdlets and aliases can do—and see examples of them in action—use PowerShell's help commands. The box on page 41 reveals what you need to know.

You can also create your own aliases using the "function" cmdlet—we touch on this in the profiles box on page 42.

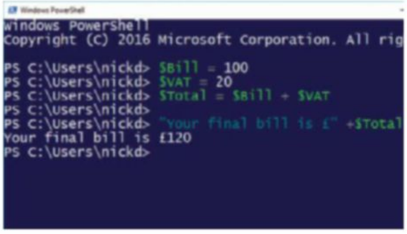
USING PARAMETERS

Just like regular Command Prompt commands, cmdlets are controlled using various parameters (also referred to as switches and flags). The "Help" box on page 41 reveals how to identify what a cmdlet's parameters are, and what they do, plus see some examples.

PowerShell also supports variables, which should be preceded with a $ string. Each variable is defined on its own line, and then that variable can be called later on. For example, try the following lines:

```
> $Bill = 100
> $TAX = 20
> $Total = $Bill + $TAX
> "Your final bill is" +$Total
```

As an aside, you could write "Your final bill is $Total" and that would work, too, because PowerShell is smart enough to recognize that $Total is variable. On other hand, if you wanted to write $Total as a word and not the variable, use 'Your final bill is $Total' instead. (More on command syntax in a minute.) You'll come across a special variable ($_) that may or may not precede something else, such as "$_.status." This is a placeholder, and we'll look at it later.



```
Windows PowerShell
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PS C:\Users\nickd> $Bill = 100
PS C:\Users\nickd> $VAT = 20
PS C:\Users\nickd> $Total = $Bill + $VAT
PS C:\Users\nickd>
PS C:\Users\nickd> "Your final bill is £" +$Total
Your final bill is £120
PS C:\Users\nickd>
```

Variables are used for storing text, numbers, and other data.

MORE COMMAND SYNTAX

PowerShell uses standard scripting operators to help build commands—everything from commas to separate items in a list, to enclosing text strings in double quotation marks (as you saw earlier, PowerShell is smart enough to identify variables inside quote marks). There are also some handy conditional operators you can use when creating conditional statements. Use "-eq" to mean equals, and "-ne" to mean not equal. Enter "-gt" for greater than (and "-ge" for greater than or equal), or "-lt" and "-le" for less than or less than or equal.

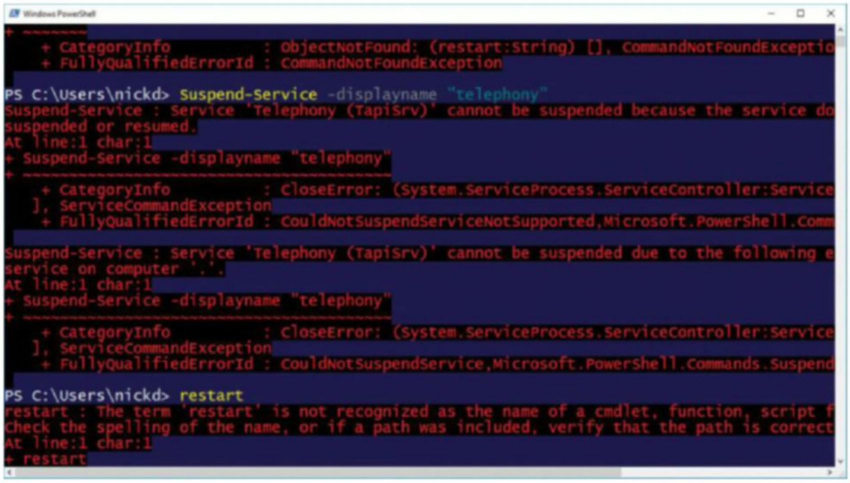
The pipe symbol—"|"—combines two or more commands in a single line of code. It's used to "pipe" the output of one command so it becomes the input of the next command. If you type "ping pcgamer.com" you'll see a list of text describing the results—now type the following command:

```
> Ping pcgamer.com | Select-String
packets | Out-File tempfile.txt
```

This pings pcgamer.com as before, but this time it searches the output for lines containing "packet," then saves them into a tempfile.txt file, which it saves to the current working directory. Open File Explorer to locate the file—it contains a single line of text, something like "Packets: Sent = 4, Received = 4, Lost = 0 (0% loss)."

CONDITIONAL STATEMENTS

Sometimes you want your commands to process differently depending on whether or not



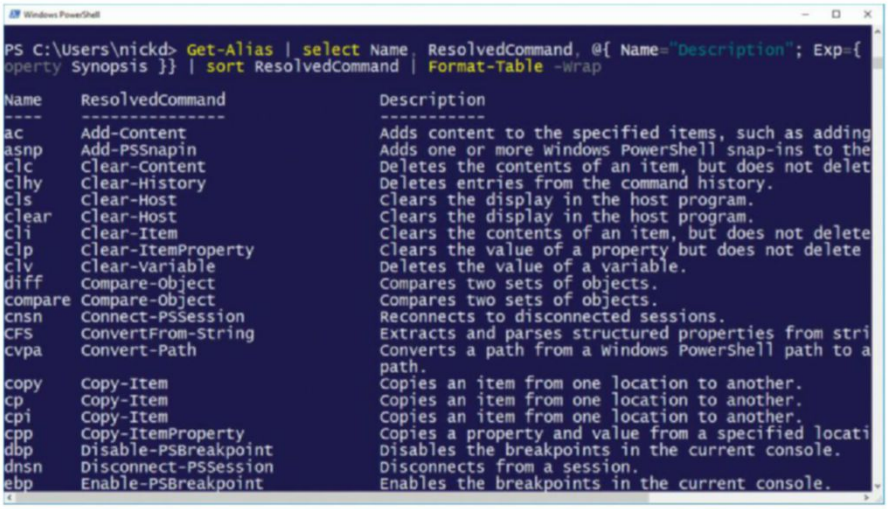
```
+ ~~~~~~~
    + CategoryInfo          : ObjectNotFound: (restart:String) [], CommandNotFoundExceptio
    + FullyQualifiedErrorId : CommandNotFoundException

PS C:\Users\nickd> Suspend-Service -displayname "telephony"
Suspend-Service : Service 'Telephony (TapiSrv)' cannot be suspended because the service do
suspended or resumed.
At line:1 char:1
+ Suspend-Service -displayname "telephony"
+ ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
    + CategoryInfo          : CloseError: (System.ServiceProcess.ServiceController:Service
   ], ServiceCommandException
    + FullyQualifiedErrorId : CouldNotSuspendServiceNotSupported,Microsoft.PowerShell.Comm

Suspend-Service : Service 'Telephony (TapiSrv)' cannot be suspended due to the following e
service on computer '.'.
At line:1 char:1
+ Suspend-Service -displayname "telephony"
+ ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
    + CategoryInfo          : CloseError: (System.ServiceProcess.ServiceController:Service
   ], ServiceCommandException
    + FullyQualifiedErrorId : CouldNotSuspendService,Microsoft.PowerShell.Commands.Suspend

PS C:\Users\nickd> restart
restart : The term 'restart' is not recognized as the name of a cmdlet, function, script f
Check the spelling of the name, or if a path was included, verify that the path is correct
At line:1 char:1
+ restart
```

PowerShell makes the effort to provide useful error messages.



```
PS C:\Users\nickd> Get-Alias | select Name, ResolvedCommand, @{ Name="Description"; Exp={
operty Synopsis }} | sort ResolvedCommand | Format-Table -Wrap

Name    ResolvedCommand                Description
----    ---------------                -----------
ac      Add-Content                    Adds content to the specified items, such as adding
asnp    Add-PSSnapin                   Adds one or more Windows PowerShell snap-ins to the
clc     Clear-Content                  Deletes the contents of an item, but does not delet
clhy    Clear-History                  Deletes entries from the command history.
cls     Clear-Host                     Clears the display in the host program.
clear   Clear-Host                     Clears the display in the host program.
cli     Clear-Item                     Clears the contents of an item, but does not delete
clp     Clear-ItemProperty             Clears the value of a property but does not delete
clv     Clear-Variable                 Deletes the value of a variable.
diff    Compare-Object                 Compares two sets of objects.
compare Compare-Object                 Compares two sets of objects.
cnsn    Connect-PSSession              Reconnects to disconnected sessions.
CFS     ConvertFrom-String             Extracts and parses structured properties from stri
cvpa    Convert-Path                   Converts a path from a Windows PowerShell path to a
                                       path.
copy    Copy-Item                      Copies an item from one location to another.
cp      Copy-Item                      Copies an item from one location to another.
cpi     Copy-Item                      Copies an item from one location to another.
cpp     Copy-ItemProperty              Copies a property and value from a specified locati
dbp     Disable-PSBreakpoint           Disables the breakpoints in the current console.
dnsn    Disconnect-PSSession           Disconnects from a session.
ebp     Enable-PSBreakpoint            Enables the breakpoints in the current console.
```

It's possible to create quite complex commands by combining cmdlets together.

specific conditions are met. Like all good scripting and programing languages, PowerShell supports this through "If" and "Else" statements (as well as variants, such as "ForEach"). The basic structure for conditional commands is this:

```
> If (condition) {perform task if condition is met or true}
```

You'll see two different types of bracket have been referenced here. Use parentheses (regular brackets) for required options within the loop. Your conditions can include "-And," "-Not," and "-Or" flags to provide more complex conditions. For example, the following performs the task if either test1 or test2 conditions are met:

```
> If (test1 -Or test2) {perform task}
```

Replace "-Or" with "-And," and both test conditions would be required; change it to "-Not," and test1 would need to be met and test2 specifically not met for the task to run.

Curly braces—{}—can also be used for block expressions within a command that explicitly looks for a condition to be met. For example, the "Where-Object" cmdlet allows you to filter data returned by other cmdlets, as the following example demonstrates:

```
> Get-Service | Where-Object {$_.status -eq "stopped"}
```

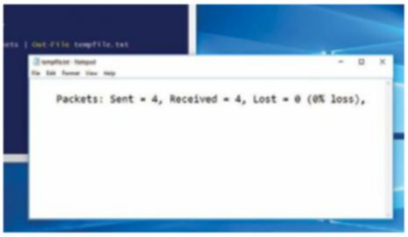
This produces a list of services on your PC that aren't currently running. The "$_" placeholder enables you to capture the output of "Get-Service" without having to run the command again. The "status" portion of the variable is a specific child property linked to "Get-Service." You can find out what these are using the "Get-Member" command, like so:

```
> Get-Service | Get-Member
```

Last, but not least, you can also use square brackets—[]—which represent optional elements that aren't required for a cmdlet to run. For example:

```
> Get-Service [w]*
```

This produces a filtered list of services that begin with the letter "w." Square brackets are also used for certain math functions.



```
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
```

Using pipes enables you to direct output from one cmdlet to another.

PUT IT ALL TOGETHER

You can combine cmdlets, variables, parameters, and syntax to perform quite complex tasks with what amounts to not very much code. The following example provides a complete list of aliases, their associated cmdlets, and available parameters, sorted by cmdlet name rather than alias. Look closely, and you should see some logic—the "sort" command clearly refers to "ResolvedCommand" (the cmdlet name), for example, while the "Get-Help" cmdlet pulls the information about each cmdlet's parameters. Finally, the "Format-Table" cmdlet is used to output the results neatly over three columns.

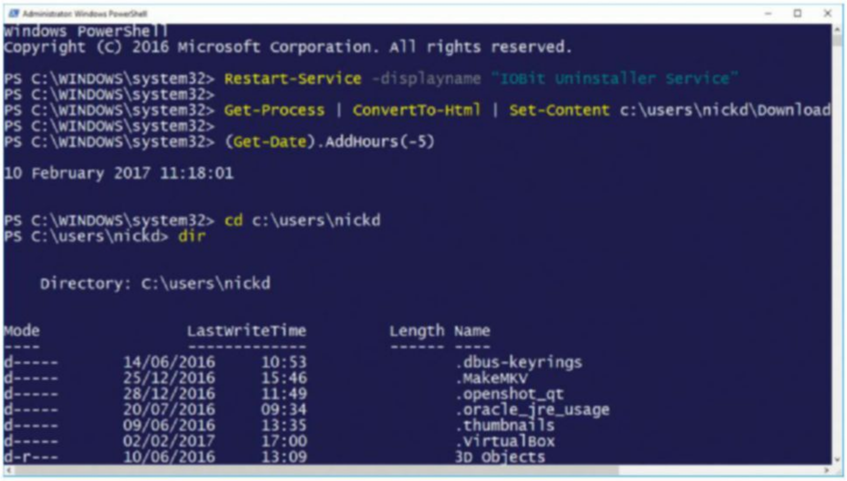
> PowerShell can also be used to manipulate services and processes.

```
> Get-Alias | select Name, ResolvedCommand, @{ Name="Description"; Exp={ Get-Help $_ | Select -ExpandProperty Synopsis }} | sort ResolvedCommand | Format-Table -Wrap
```

Before we move on, having to type these commands in full can be time-consuming, but here's a handy shortcut: start typing a cmdlet, then press Tab to auto-complete it—if more than one match is found, keep hitting Tab until your cmdlet is displayed, and press Shift-Tab to cycle back through the list in case you miss your target.

HANDY CMDLETS

Let's introduce some more cmdlets. An exhaustive A-Z list is beyond us, so bookmark the "Task-Based Guide to Windows PowerShell Cmdlets" at https://technet.microsoft.com/



```
Windows PowerShell
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PS C:\WINDOWS\system32> Restart-Service -displayname "IObit Uninstaller Service"
PS C:\WINDOWS\system32>
PS C:\WINDOWS\system32> Get-Process | ConvertTo-Html | Set-Content c:\users\nickd\Download
PS C:\WINDOWS\system32>
PS C:\WINDOWS\system32> (Get-Date).AddHours(-5)

10 February 2017 11:18:01


PS C:\WINDOWS\system32> cd c:\users\nickd
PS C:\users\nickd> dir


    Directory: C:\users\nickd


Mode                LastWriteTime         Length Name
----                -------------         ------ ----
d-----       14/06/2016     10:53                .dbus-keyrings
d-----       25/12/2016     15:46                .MakeMKV
d-----       28/12/2016     11:49                .openshot_qt
d-----       20/07/2016     09:34                .oracle_jre_usage
d-----       09/06/2016     13:35                .thumbnails
d-----       02/02/2017     17:00                .VirtualBox
d-r---       10/06/2016     13:09                3D Objects
```

PowerShell's cmdlets can perform a huge variety of tasks.

en-us/library/dd772285.aspx. It's organized into tasks under such groups as "Dates and Times," "Files and Folders," "Help and Information," "Scripting Techniques," and "System Administration Tasks."

First up, the "Get-Date" cmdlet lists the date and time—use the "-displayhint" parameter, and specify either date or time to filter the output. You can also use "Get-Date" to specify a variable using date/time format, and to perform various forms of time- or date-based arithmetic, using such parameters as "AddSeconds" through to "AddYears." The following is a handy way to quickly calculate time offsets for different parts of the world:

```
> (Get-Date).AddHours(-5)
```

Next, use "Copy-Item" to copy files or folders to a new location—you need to specify the source, then the destination. Use the wildcard (*) character to copy all files in a folder to the location, or "*.doc" to restrict it to copying only specific file types:

```
> Copy-Item c:\users\nickd\documents\
scripts\*.ps1 c:\users\nickd\downloads\test\
```

Related file-based cmdlets include "Remove-Item" (delete), "Move-Item," "Rename-Item," and "New-Item" (create a file or folder—use the "-type" parameter to specify "file" or "directory' respectively).

We've touched on using "Out-File" to record a command's output to a text file, but what if you want to append a string of text to an existing file, instead of creating one? The "Add-Content" cmdlet does just that. By default, it appends your string immediately after the last character in the file, but it's likely you'll want to append it to a new line, so precede your text with "`n," like so:

```
> Add-Content c:\users\nickd\
documents\text.txt "`nThe End"
```

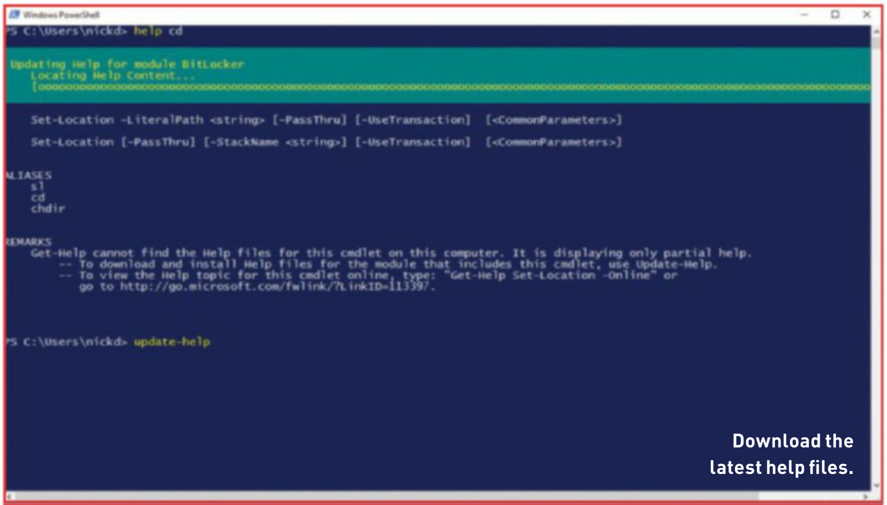
Want to output your command to a web page? Use the "ConvertTo-Html" cmdlet in a piped command, in conjunction with a "Get-" command and "Set-Content" (which does the actual writing of data):

```
> Get-Process | ConvertTo-Html | Set-
Content c:\user\nickd\downloads\test.htm
```

PowerShell can be used to manipulate services (and processes), using a number of different cmdlets. Available commands—all self-explanatory, and requiring you to run PowerShell as an administrator—include "Start-Service," "Stop-Service," "Restart-Service," "Suspend-Service," and "Resume-Service." These need to be followed by the service's name as stored in the Registry—if you don't know this, use the "-displayname" parameter, in conjunction with the name of the service, as it appears under services.msc:

```
> Restart-Service -displayname "File
History Service"
```

Note, you may see an error message appear if you attempt to pause the vast



```
S C:\Users\nickd> help cd

Updating Help for module BitLocker
   Locating Help Content...
   [oooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo

    Set-Location -LiteralPath <string> [-PassThru] [-UseTransaction]  [<CommonParameters>]

    Set-Location [-PassThru] [-StackName <string>] [-UseTransaction]  [<CommonParameters>]


LIASES
    sl
    cd
    chdir


EMARKS
    Get-Help cannot find the Help files for this cmdlet on this computer. It is displaying only partial help.
        -- To download and install Help files for the module that includes this cmdlet, use Update-Help.
        -- To view the Help topic for this cmdlet online, type: "Get-Help Set-Location -Online" or
           go to http://go.microsoft.com/fwlink/?LinkID=113397.



S C:\Users\nickd> update-help
```

Download the latest help files.

GET HELP

There's plenty of help—offline and online—waiting for you with PowerShell. The obvious place to start is with its own built-in help tools. Type the following:

```
> help cmdlet
```

Replace "cmdlet" with your cmdlet's or alias's name. You'll receive a prompt that the more detailed help files require installing, but to avoid a string of error messages, first close and restart PowerShell as an administrator, then type:

```
> Update-Help
```

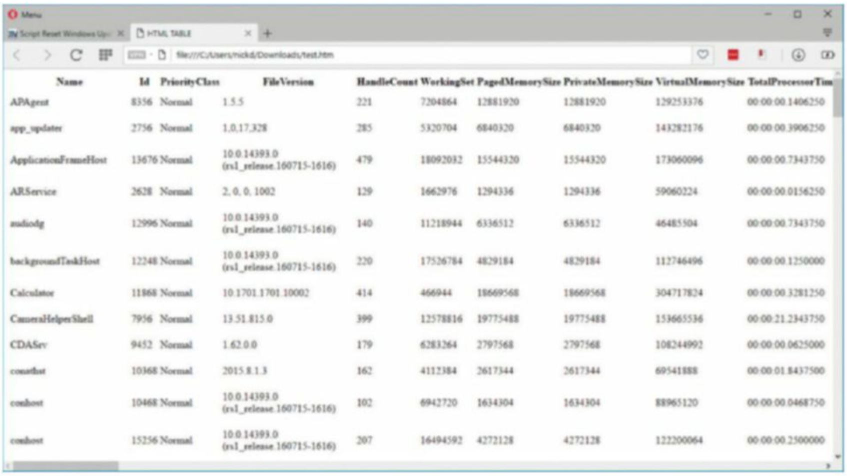
A green progress bar appears, and then the files are added, one module at a time—don't be surprised to end with an error message or two, which can be safely ignored. Close and restart PowerShell again.

Now the help files have been replaced, use the following command:

```
> Get-Help cmdlet
```

You can add some handy parameters: "-detailed" ("Get-Help cmdlet -detailed") provides a list of all available parameters for that cmdlet, plus examples of them in action. Use "-examples" if you only want to view examples. One downside of the help file is that you need to keep scrolling back to reference it; add "-online" and it opens in your browser, enabling you to view it side-by-side while coding.

You'll also find lots of websites providing you with more help and advice, too. One of our favorites can be found at www.computerperformance.co.uk/powershell/—although written for an older version of PowerShell, its basic advice holds true, and it provides a good reference guide, with a handy, if labyrinthine, navigation panel. There's a useful A-Z reference of cmdlets at https://ss64.com/ps/, and don't forget to check Microsoft's Developer Network at https://msdn.microsoft.com/en-us/powershell for lots more resources—go to "Documentation → Windows PowerShell" for a detailed introduction.



Name	Id	PriorityClass	FileVersion	HandleCount	WorkingSet	PagedMemorySize	PrivateMemorySize	VirtualMemorySize	TotalProcessorTim
APAgent	8356	Normal	1.5.5	221	7204864	12881920	12881920	129253376	00:00:00.1406250
app_updater	2756	Normal	1.0.17.328	285	5320704	6840320	6840320	143282176	00:00:00.3906250
ApplicationFrameHost	13676	Normal	10.0.14393.0 (rs1_release.160715-1616)	479	18092032	15544320	15544320	173060096	00:00:00.7343750
ARService	2628	Normal	2, 0, 0, 1002	129	1662976	1294336	1294336	59060224	00:00:00.0156250
audiodg	12996	Normal	10.0.14393.0 (rs1_release.160715-1616)	140	11218944	6336512	6336512	46485504	00:00:00.7343750
backgroundTaskHost	12248	Normal	10.0.14393.0 (rs1_release.160715-1616)	220	17526784	4829184	4829184	112746496	00:00:00.1250000
Calculator	11868	Normal	10.1701.1701.10002	414	466944	18669568	18669568	304717824	00:00:00.3281250
CameraHelperShell	7956	Normal	13.51.815.0	399	12578816	19775488	19775488	153665536	00:00:21.2343750
CDASrv	9452	Normal	1.62.0.0	179	6283264	2797568	2797568	108244992	00:00:00.0625000
conathst	10368	Normal	2015.8.1.3	162	4112384	2617344	2617344	69541888	00:00:01.8437500
conhost	10468	Normal	10.0.14393.0 (rs1_release.160715-1616)	102	6942720	1634304	1634304	88965120	00:00:00.0468750
conhost	15256	Normal	10.0.14393.0 (rs1_release.160715-1616)	207	16494592	4272128	4272128	122200064	00:00:00.2500000

The "ConvertTo-HTML" cmdlet is crude, but effective nonetheless.

majority of services that don't support being paused and resumed. That's normal, and like all PowerShell error messages, there's usually enough information provided to help you grasp what's going on.

BUILD A COMMAND

We have touched on how cmdlets work best when used in conjunction with others to form complete commands. Here's a practical example of how to use PowerShell to change the message colors it displays, with the help of the "Get-Host" cmdlet. Start by typing the following, to see how PowerShell currently displays warning messages:

```
> Write-Warning "Alert!"
```

You'll see the message is displayed as yellow text on a black background, which is fine, unless you've modified the background and font colors, as outlined earlier. So how do you go about changing it? Easy. We use the "Get-Host" cmdlet to extract the current properties of the command window using its "PrivateData" property (which is anything but private—oh the irony):

```
> $a = (Get-Host).PrivateData
> echo $a
```

This reveals no fewer than 10 child properties for "PrivateData," including two referring to warning colors. We can then change these, like so:

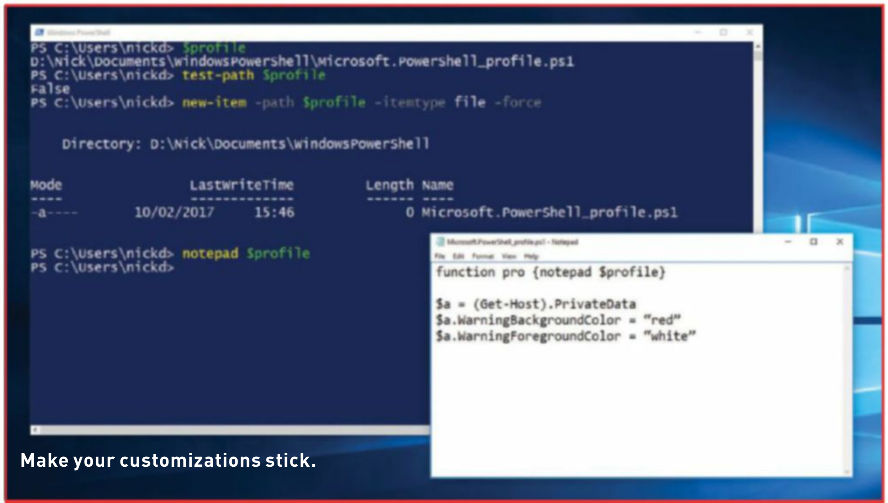
```
> $a.WarningBackgroundColor = "red"
> $a.WarningForegroundColor = "white"
```

Now try the "Write-Warning" cmdlet again. Note, however, that the changes won't survive the current PowerShell session—close the window and open it again, and you're back to the original settings. This leads us on to the concept of PowerShell profiles, which you can find out more about in the box on the left.

BUILDING SCRIPTS

Scripting is a way of storing and running multiple commands from a single file. Command Prompt scripts are written as plain text files, and saved using the .bat extension. Each command is placed on a separate line, and they're run in sequence when the batch file is called from the Command Prompt by navigating to the directory the script is stored in, typing its name—"script.bat," for example—and hitting Enter.

PowerShell supports scripts, too—again, these are text files, but they're stored using the .ps1 file extension. They're then called from the PowerShell command prompt—if



```
PS C:\Users\nickd> $profile
D:\Nick\Documents\WindowsPowerShell\Microsoft.PowerShell_profile.ps1
PS C:\Users\nickd> test-path $profile
False
PS C:\Users\nickd> new-item -path $profile -itemtype file -force


    Directory: D:\Nick\Documents\WindowsPowerShell


Mode                LastWriteTime         Length Name
----                -------------         ------ ----
-a----       10/02/2017     15:46              0 Microsoft.PowerShell_profile.ps1


PS C:\Users\nickd> notepad $profile
PS C:\Users\nickd>
```

```
function pro {notepad $profile}

$a = (Get-Host).PrivateData
$a.WarningBackgroundColor = "red"
$a.WarningForegroundColor = "white"
```

Make your customizations stick.

BUILD A PROFILE

By default, everything you set up in PowerShell—variables, functions, and other customizations, such as the color of warning messages—is lost when you close the current session. If you'd like to preserve this across multiple sessions, you need to create a profile. First, display the path to the Windows PowerShell profile by typing:

```
> $profile
> test-path $profile
```

This reveals that the profile will reside in your Documents folder, while the second command returns a value of "False," indicating that the profile doesn't yet exist. To create a profile, type:

```
> new-item -path $profile -itemtype file -force
```

Type the following to open it in Notepad:

```
> notepad $profile
```

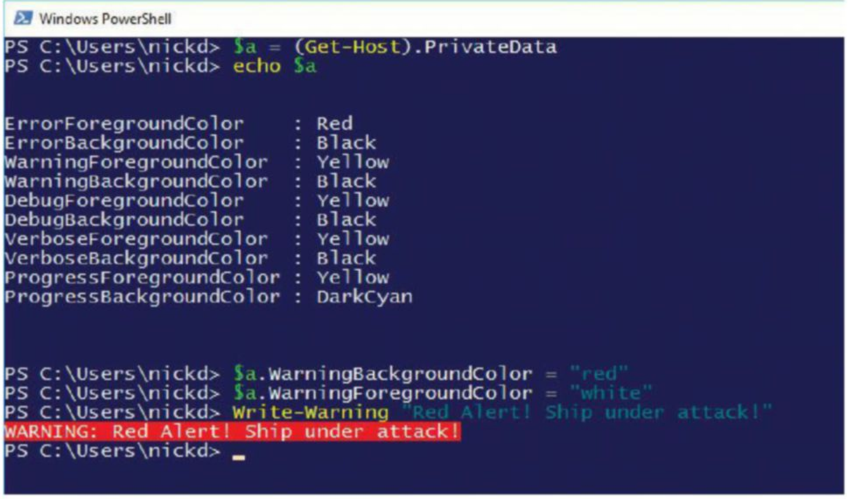
A blank document is opened, ready for you to record your variables and other customizations. For example, to change the warning message as outlined in the main text, add the following three lines of code:

```
$a = (Get-Host).PrivateData
$a.WarningBackgroundColor = "red"
$a.WarningForegroundColor = "white"
```

Add the following line, and you can edit your profile simply by issuing the command "pro" into PowerShell going forward:

```
function pro {notepad $profile}
```

Save the file in Notepad, then close and reopen PowerShell—your customizations should be in place. It basically works like a script file, but is loaded each time you launch PowerShell. It only affects PowerShell when you run it as the current user—if you want to create a profile that affects all users and shells, simply launch PowerShell as an administrator instead. The profile is stored inside the Windows\System32 folder, and applies to all users of your PC.

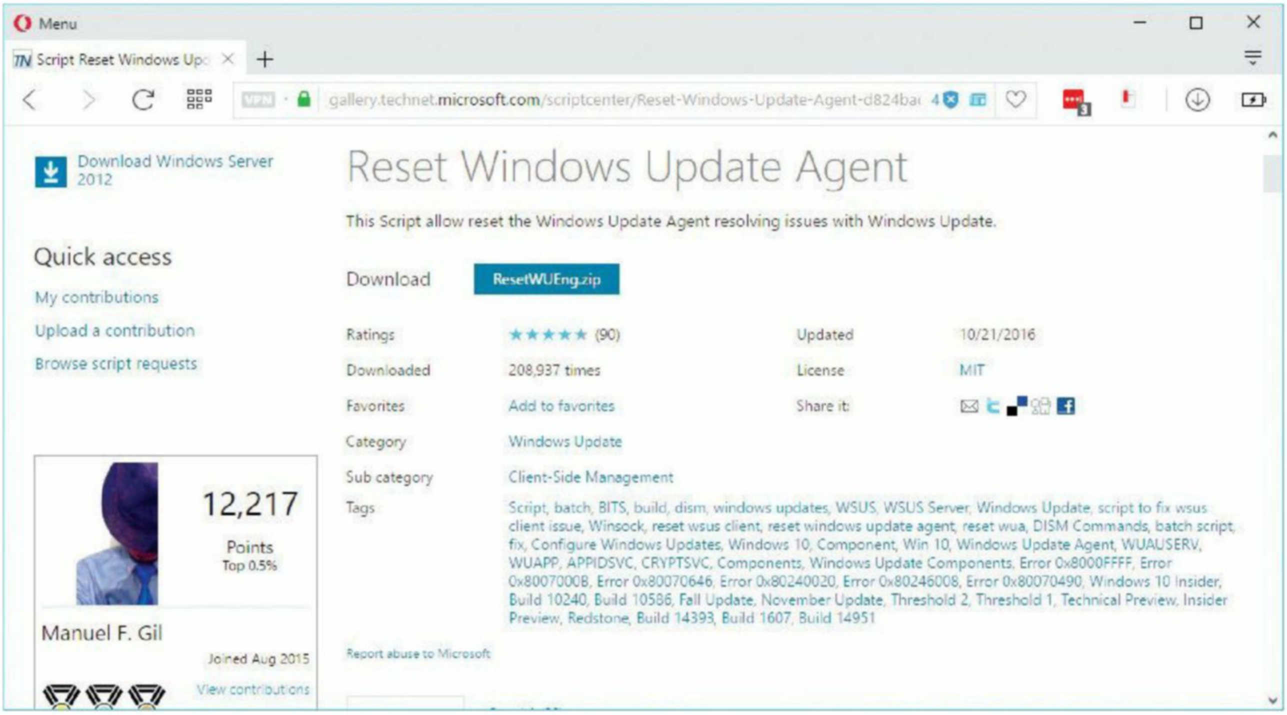


```
PS C:\Users\nickd> $a = (Get-Host).PrivateData
PS C:\Users\nickd> echo $a

ErrorForegroundColor    : Red
ErrorBackgroundColor    : Black
WarningForegroundColor  : Yellow
WarningBackgroundColor  : Black
DebugForegroundColor    : Yellow
DebugBackgroundColor    : Black
VerboseForegroundColor  : Yellow
VerboseBackgroundColor  : Black
ProgressForegroundColor : Yellow
ProgressBackgroundColor : DarkCyan


PS C:\Users\nickd> $a.WarningBackgroundColor = "red"
PS C:\Users\nickd> $a.WarningForegroundColor = "white"
PS C:\Users\nickd> Write-Warning "Red Alert! Ship under attack!"
WARNING: Red Alert! Ship under attack!
PS C:\Users\nickd> _
```

Use PowerShell cmdlets to change the color of your text.



Reset Windows Update Agent

This Script allow reset the Windows Update Agent resolving issues with Windows Update.

Download: ResetWUEng.zip

Ratings	★★★★★ (90)	Updated	10/21/2016
Downloaded	208,937 times	License	MIT
Favorites	Add to favorites	Share it:	
Category	Windows Update		
Sub category	Client-Side Management		
Tags	Script, batch, BITS, build, dism, windows updates, WSUS, WSUS Server, Windows Update, script to fix wsus client issue, Winsock, reset wsus client, reset windows update agent, reset wua, DISM Commands, batch script, fix, Configure Windows Updates, Windows 10, Component, Win 10, Windows Update Agent, WUAUSERV, WUAPP, APPIDSVC, CRYPTSVC, Components, Windows Update Components, Error 0x8000FFFF, Error 0x8007000B, Error 0x80070646, Error 0x80240020, Error 0x80246008, Error 0x80070490, Windows 10 Insider, Build 10240, Build 10586, Fall Update, November Update, Threshold 2, Threshold 1, Technical Preview, Insider Preview, Redstone, Build 14393, Build 1607, Build 14951		

There are loads of great PowerShell scripts online, such as this one, which can help fix issues with Windows Update.

your script resides in the same directory you're currently in, use the following:

```
> .\filename.ps1
```

If you need to call it from another directory, use the following syntax:

```
> & "c:\users\nickd\script.ps1"
```

The first time you attempt this, you'll receive an error message telling you that scripts can't be run. This is down to PowerShell's security policy, which is set to "Restricted" by default. You can change this policy within PowerShell, but you need to exit and relaunch it as an administrator to do so. Once done, type the following:

```
> Set-ExecutionPolicy -ExecutionPolicy
RemoteSigned
```

Press Y, and hit Enter when prompted, and try running your script again. This time, it should work—"RemoteSigned" basically allows all local scripts, as well as downloaded scripts that have been signed by a trusted publisher, to run.

While you can create scripts by hand in a text editor, Windows provides all the tools you need to build and test .ps1 scripts in PowerShell ISE, which provides a more fully rounded experience, and is geared toward making it easier and quicker to write, test, and run scripts. Check out the final box for an overview of how it works.

You've now started on your journey to tapping into scripting using PowerShell and PowerShell ISE. We've barely scratched the surface, but you should have enough of a grounding to strike out on your own. To help you move on to the next level, visit https://gallery.technet.microsoft.com/ScriptCenter, where you'll find thousands of script resources for PowerShell. They've technically been written for IT professionals, but you'll find plenty of examples that you can make use of as a regular user, too—for example, the "Reset Windows Update Agent" script enables you to attempt to fix problems with Windows Update from the PowerShell interface.

Before we go, one final use for PowerShell (run as an administrator) is to remove Windows Store apps from your PC. Use the following syntax:

```
> Get-AppxPackage *appname* |
Remove-AppxPackage
```

Substitute "appname" with the name of the app you wish to remove, and they're all up for grabs, even built-in apps ignored by Apps & Features. To get a full list, use:

```
> Get-AppxPackage -AllUser | Format-
List -Property PackageFullName
```

POWERSHELL ISE

Once you've got to grips with the basics, we recommend switching to coding, and developing scripts using PowerShell ISE (search for "ISE" in the Windows search box). It opens to a multi-pane window: the console window appears to mimic the basic PowerShell interface, but comes with some hidden extras. First, you can input and edit multiple lines of code at once—hit Shift-Enter to add an extra line.

Second, as you start typing cmdlets, the Snippets feature automatically suggests commands to enter (select them with the arrow keys, then a list of supported parameters for the selected cmdlet is displayed; press Tab to insert the cmdlet). Right-click the console window, and choose "IntelliSense" for an even more helpful tool that suggests parameters, parameter values, and even files and folders.

You'll see a functional menu bar with lots of options related to scripting, and the elusive script window can be brought into view by pressing Ctrl-R. Snippets and IntelliSense work inside here, too, and you can run all your script by pressing F5, plus save it to disk for future use. You can also run just a small portion of it—select the code in question, then hit F5 to run it in isolation from the rest of your script.

The Command panel on the right offers an alternative, interactive way of inserting cmdlets. Select one from the list for a description, then click "Insert" to insert it into your console, or click the "Show Details" to view all available parameters. Select one or add in any required information, then click "Insert" to insert a fully formed command into the console.

Finally, you can expand ISE's capabilities by choosing "Add-Ons → Open Add-Ons Website" to browse community-written snippets that add different types of functionality to ISE.

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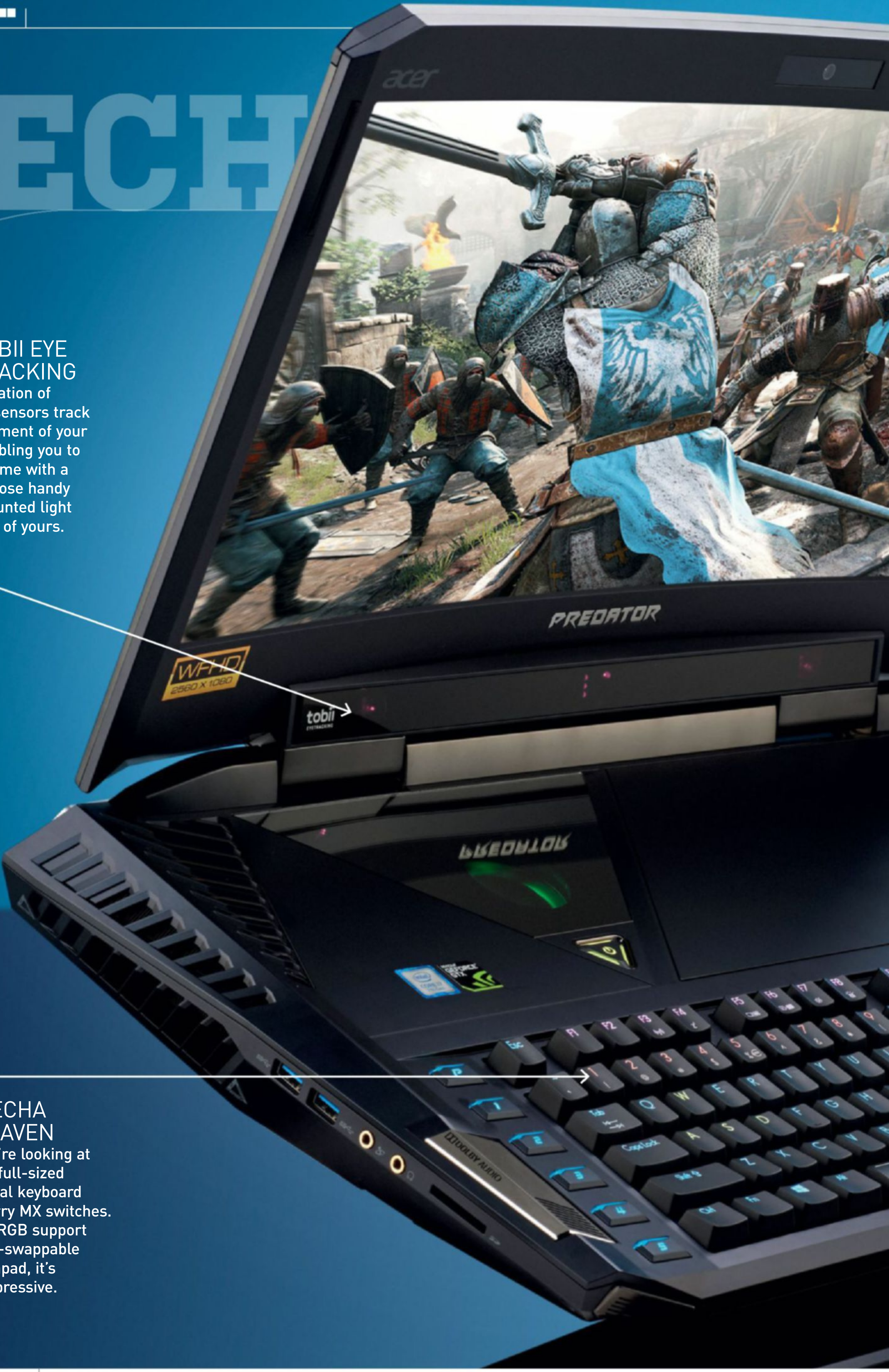
TECH


acer
PREDATOR
WFHD
2560 X 1080
tobii
PREDATOR
DOLBY AUDIO

1 TOBII EYE TRACKING

A combination of infrared sensors track the movement of your eyes, enabling you to pan in-game with a flick of those handy head-mounted light detectors of yours.

2 MECHA HEAVEN

What you're looking at here is a full-sized mechanical keyboard with Cherry MX switches. With full RGB support and a hot-swappable key/touchpad, it's damn impressive.

3 PIXEL DENSITY

That strange 2560x1080 resolution isn't as odd as you might originally think. At this size it packs a phenomenal 132 pixels per inch—that's just a touch shy of the pixel clarity of a 4K 32-inch screen.

4 GTX 1080 SLI

They don't quite pack the punch of their full-sized desktop counterparts, but these two Pascal powerhouses are more than capable of driving any of the latest titles at the native 2560x1080.

Acer Predator 21 X

NINE THOUSAND of your hard-earned dollars would buy you this behemoth. It's a gaming notebook—if you can call it that—unlike any other. A titan in its field. The pinnacle of all you could possibly achieve with the laptop form factor.

Packing an arsenal of the latest hardware, of which even the most exuberant PC enthusiast would be jealous, the 21 X sits on the cusp of a new concept: that curved screen. Sitting in front of you is a 21:9 superwide, IPS, G-Sync, curved screen, with a resolution of 2560x1080.

Powering that screen are two GeForce GTX 1080s operating in SLI, fully capable of being overclocked on demand, simultaneously co-ordinated by the phenomenal processing power of Intel's Core i7-7820HK, a four-cored, eight-threaded Kaby Lake powerhouse of a chip. On top of that, there's 64GB of DDR4, two Samsung 256GB PCIe SSDs operating in RAID 0, and a chilling cooling solution consisting of no fewer than five separate fans, most of which are Acer's patented aluminum design.

But it's raw power that tames the beast, so does the 21 X compete? The answer, rather unsurprisingly, is yes. Although not quite at the same level as its desktop counterpart, it hammers frames into the ground in quick succession with that superwide screen, making gaming on this truly beautiful.

The 21 X is, admittedly, for a select few. It's designed for people on the move. Tournament players. Those who want the pinnacle of laptop performance. And although its meaty design may be off-putting to many, there are others for which it's the epitome of everything that makes PC gaming what it is. **–ZAK STOREY**

IS 3D XPOINT INTEL'S SECRET WEAPON?

Jeremy Laird asks, what is 3D XPoint? A supercharged flash alternative or the gateway to 100GHz optical computing?

intel
OPTANE
MEMORY

Is Intel's new 3D XPoint tech the biggest paradigm shift in computing since the introduction of silicon chips? Is it merely the basis of faster SSDs? Or is this story nothing more than a combination of vaporware and conspiracy theories?

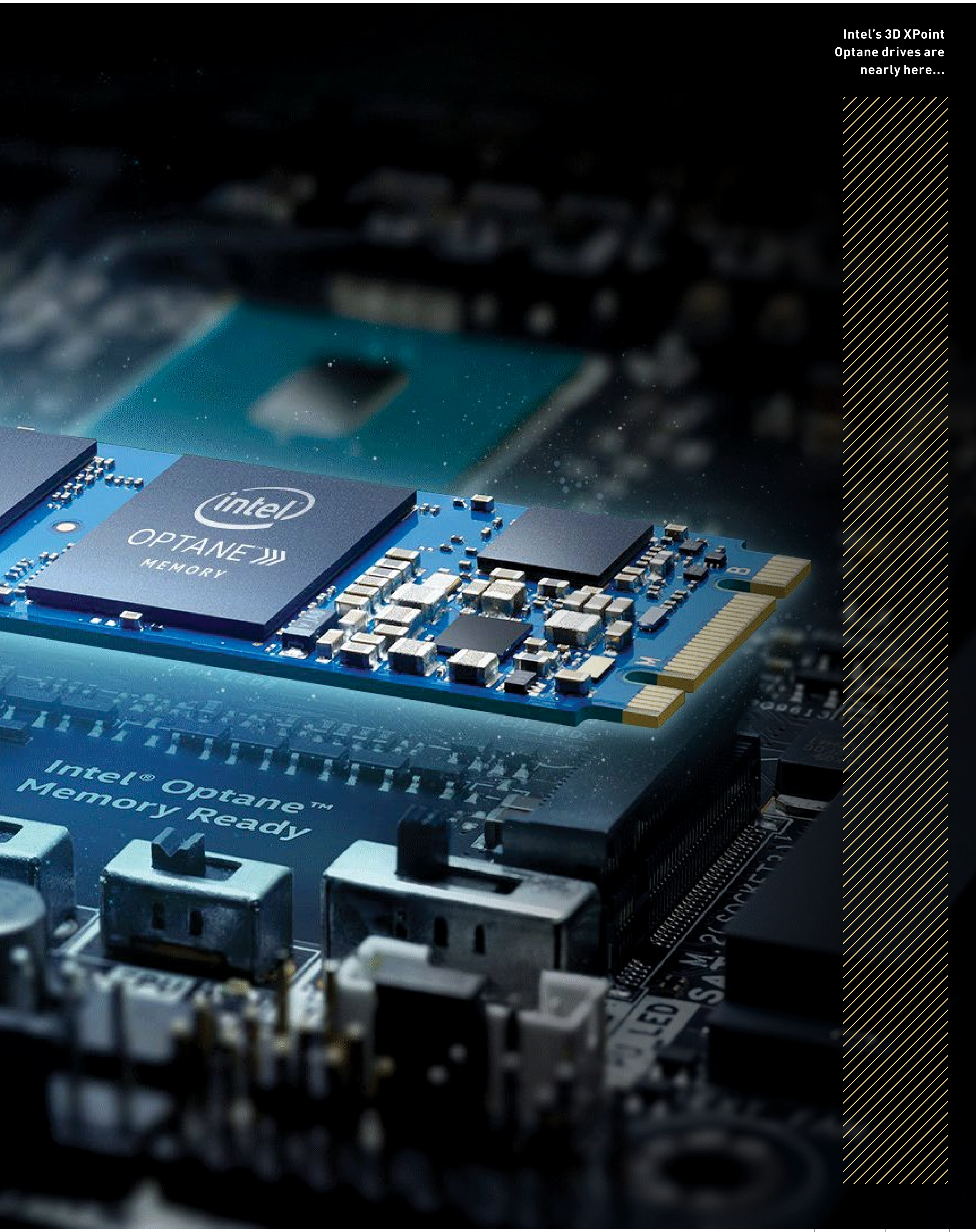
3D XPoint is one of the most mysterious technologies to come out of Intel in years. The first products derived from it are imminent, yet we don't fully understand what it is or how it works. It's not even totally clear what it's really intended to do.

Partly that's down to a lack of clarity on Intel's (and its partner, Micron's) behalf. The messaging has been mixed, both in terms of the intended applications for 3D XPoint, and the insight Intel has provided into its technical underpinnings. It's the latter, in particular, that has fueled speculation. Nature abhors a vacuum, and into the space created by equivocation has flowed extensive conjecture.

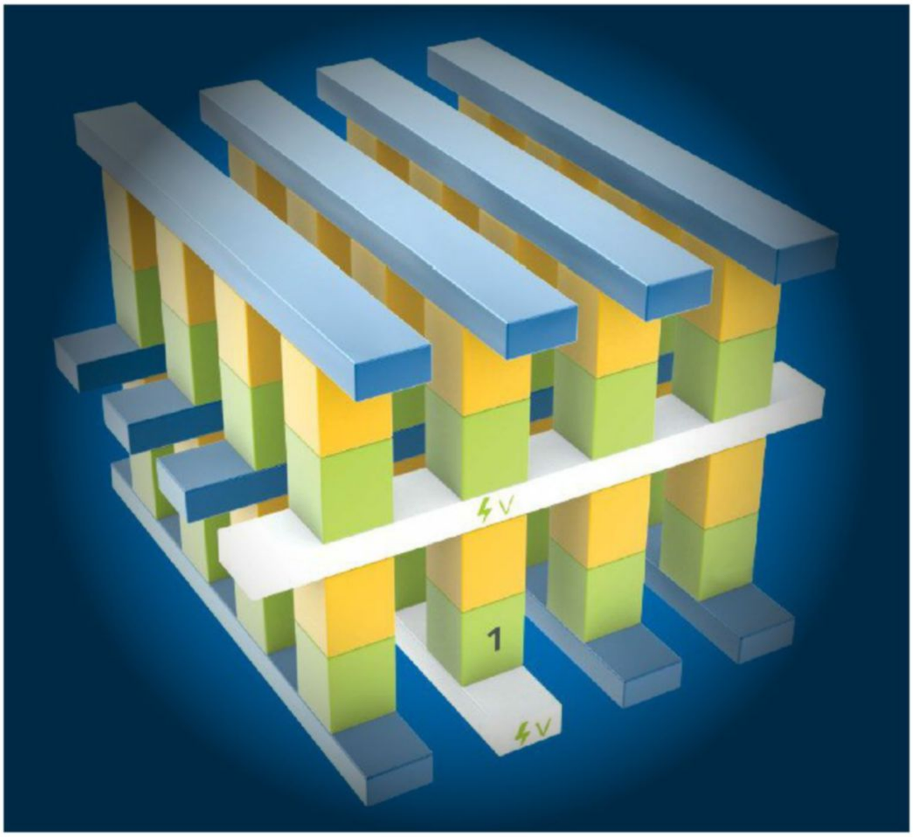
Is 3D XPoint the basis for a whole new approach to chips, with chalcogenide and phase-change materials replacing silicon and the transistor? Does it open the door to fully integrated on-chip optical computing? Will it smash the circa-4GHz ceiling on CPU speeds, achieving frequencies in hundreds of gigahertz?

Meanwhile, rumors abound of corporate maneuvering and even skulduggery. Is the patchy technical insight an attempt to protect valuable and vulnerable intellectual property? Could Intel be playing down the true value of 3D XPoint, while it scoops up the relevant patents, ensuring a lucrative lockdown on the next age of computing? Could there be an intentional cover-up involving infringement of third-party patents?

Heady stuff. Getting to the truth, however, isn't easy. All we know is that the first 3D XPoint products will take the form of non-volatile solid-state storage, sold under the new Intel Optane brand. But even here, there's scope for confusion. The first Optane drives aren't intended to replace system memory or hard drives. Instead, they're somewhere in between—a kind of fast cache designed to act as a buffer in front of the relatively slow performance of an SSD containing NAND flash memory. With that, let us begin....


intel
OPTANE
MEMORY
Intel® Optane™ Memory Ready

Intel's 3D XPoint Optane drives are nearly here...



The structure of 3D XPoint is surprisingly simple.

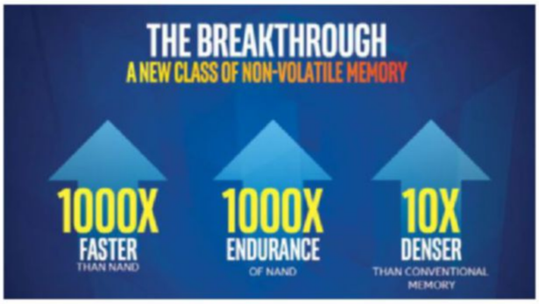
When 3D XPoint was first mooted, it was exciting simply as a new memory technology, let alone as the foundation for a whole new approach to computer chips. The industry has spent decades trying to cook up a new non-volatile storage technology with which to improve upon flash memory. Finally, here it is.

The sales pitch was stellar. In early presentations, Intel said 3D XPoint was up to 1,000 times faster and 1,000 times more durable than existing NAND flash memory. Even by the standards of the chip industry, for which exponential improvements over time are the norm, that kind of one-off step change is exotic.

The commercial reality isn't proving quite so spectacular. The first retail products based on 3D XPoint are just about to hit the market under Intel's Optane branding, and expectations have been scaled back dramatically. Specific performance data hasn't been released. But Intel is talking about Optane drives being up to 10 times faster than a conventional SSD. Still a big jump, but perhaps rather more plausible.

Let's not get ahead of ourselves. First, let's lay out what we know about 3D XPoint. Currently, there are two prevailing memory technologies, if we're talking integrated circuits rather than magnetic memory solutions, such as a hard disk. RAM or system memory is super fast and effectively lasts forever, but requires a constant electrical current. NAND or flash memory is non-volatile, so maintains data integrity without a power supply, but at the expense of speed and durability.

There are a few other details that separate the two, such as memory cell size and power consumption, both of which are relatively poor with RAM. But the holy grail for the last 20 to 30 years has been to develop a memory technology that combines the best of both: speed and durability with non-volatility. Several technologies and even whole companies promising just such a solution have come and gone over the past few decades. But 3D XPoint is arguably the first that really looks like it's going to stick.



THE BREAKTHROUGH

A NEW CLASS OF NON-VOLATILE MEMORY

1000X FASTER THAN NAND

1000X ENDURANCE OF NAND

10X DENSER THAN CONVENTIONAL MEMORY

Intel is making big claims for 3D XPoint performance.

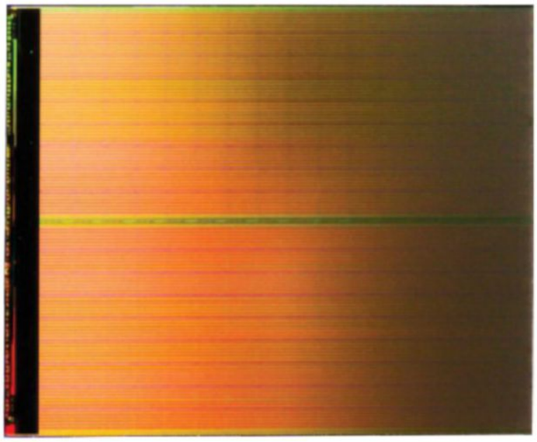
It's actually the work—or at least the property—of two of the biggest players in computer chips in general, Intel and Micron. The former is best known today as a maker of PC processors. But Intel's genesis was actually as a maker of memory. Its first product was in fact DRAM, or dynamic random access memory, which remains the basis of system memory in PCs and other computing devices today. Micron, meanwhile, is well known as a maker of all kinds of memory, from sticks of DDR to solid-state drives, many of which sell under its Crucial retail branding.

Although 3D XPoint may eventually end up replacing both DRAM and NAND, for now it's the latter that begs the most obvious comparison, not least because it, too, is a non-volatile memory type. But there are huge differences thereafter. NAND, for instance, stores data by trapping electrons in an insulated floating gate. Thus, each memory cell is a sort of capacitor, with the charged or discharged state representing a bit of data.

3D XPoint, by contrast, is a resistance-based technology that uses bulk property change to the cell material to alter its resistance level, and so record a memory state. When you drill right down to cell level, 3D XPoint also has a remarkably simple structure. There's the memory cell itself, a switch or selector element, then the connecting wires. And that's really it. The cleverness comes in the materials, and how it's all arranged.

Currently, Intel and Micron haven't revealed all the details, leaving space for speculation as to the full implications of the technology. But what is clear is that the bitline and wordline connecting wires are arranged above and below the cells, and laid perpendicular to one another, in a grid pattern, hence the "XPoint," or crosspoint, moniker.

There are some immediate benefits that come out of all that. For starters, the simplicity of the structure, including the notable lack of a transistor, makes for excellent cell density. In other words, you can pack in more data, especially



Get a load of the first 3D XPoint wafers....

compared to DRAM. What's more, the "crosspoint" wiring means the data is addressable at individual bit level. This has all kinds of upsides compared to NAND flash, which must be read and written in large blocks.

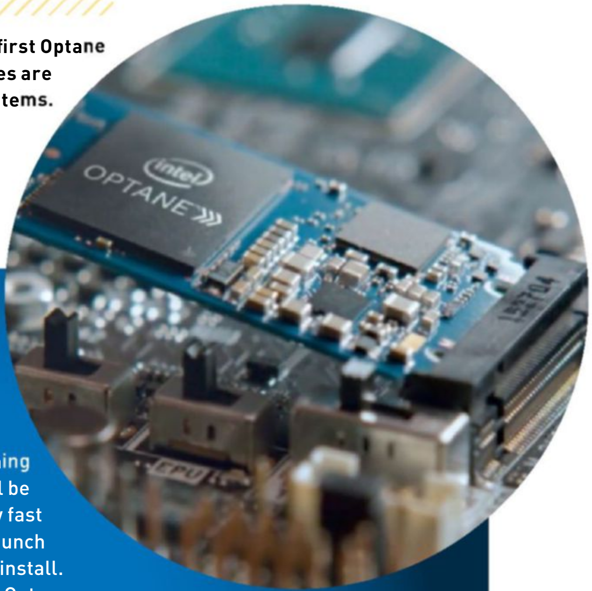
The latter is a reasonable approach when reading or writing large chunks of data, but it quickly becomes inefficient with random access workloads involving high frequency requests to read and write little snippets of data. The net result is that you end up reading and writing large amounts of redundant data. By enabling bit-level access to data, 3D XPoint has NAND flash dramatically beaten for speed and latency.

As we mentioned earlier, 3D XPoint is also claimed to offer up to 1,000 times better endurance than NAND. That makes for something in the order of a few million write-erase cycles, or hundreds of petabytes of writes overall, and hundreds of terabytes of writes per day. So, for most users, an SSD using 3D XPoint technology could be considered to last forever. It will never wear out.

Overall, the broad picture for the first implementation of 3D XPoint in Optane drives puts its capabilities roughly between DRAM and NAND, but arguably closer to the former. It's far faster than NAND, but not as fast as DRAM. Likewise, it's much denser than DRAM in terms of data storage, but not quite as dense as NAND.

If that's what we know for sure today, how will 3D XPoint deliver in the future, and could it really be the beginning of a new age of computing? In the short to medium term, it seems fairly certain that Optane drives will transition from cache drives into general storage. The first Optane products have been announced at 16GB and 32GB capacities, using a production node roughly equivalent to 20nm transistors (without any transistors, direct comparisons of feature size become quite subjective), reflecting the relatively high cost of the very first 3D XPoint chips. Prices haven't been announced, but as Intel and Micron get to grips with production, we expect to see the cost come down fairly rapidly. Within a couple of years at most, Optane drives measuring hundreds of gigabytes and more should be available at prices normal consumers can afford.

It's everything beyond that where things get complicated. For instance, co-CEO Guy Blalock of the IMFT Intel-Micron joint venture responsible for 3D XPoint has said, "3D XPoint specifically offers a path to provide massive amounts of memory storage at a latency rate sufficient to place it in close proximity to the CPU." Intriguing, but what does it actually mean? It's not exactly saying that 3D XPoint is poised to replace DRAM. But it's also placing it in an



The first Optane drives are M.2 items.

INTEL'S OPTANE:
3D XPOINT IS GO FOR LAUNCH

It's going to be a while before we'll be able to uncover the full implications of Intel's 3D XPoint tech. But we do now know what shape the first products will take. At CES in Las Vegas, earlier this year, Intel divulged initial details of its first 3D XPoint products.

To be sold under the new Optane brand, we're talking solid-state storage in the M.2 form factor, and initially 16GB and 32GB capacities. Somewhat oddly, the marketing pitch for Optane has involved the shortcomings of using a "spinning hard disk" for data storage. That's true, of course, but the fact that Optane drives are solid state and faster than magnetic hard drives surely isn't what sets them apart. It's the distinction compared to existing solid-state drives that makes Optane interesting.

Whatever, Optane drives are being pitched as a disk drive cache memory option for its seventh-gen Kaby Lake processors and platforms. To quote: "Intel Optane memory is a revolutionary new memory technology that affordably accelerates your system, delivering high speed and responsiveness without compromising system storage capacity. When combined with a large storage drive, the Intel Optane memory M.2 module accelerates computer performance, while maintaining capacity. You'll be amazed at how fast applications launch or new games install. Together, Intel Optane memory and a seventh-generation Intel Core i-series processor deliver a snappy PC experience with short boot times, fast application launches, extraordinary gaming experience, and responsive browsing."

You will, as we understand it, need the full Kaby Lake package to use an Optane drive. That means a Core iSomething-7xxx CPU and a motherboard with Optane support, based on Intel's new 200 Series chipsets. Exactly what we can expect in terms of performance boosts, whether Optane will play nicely with both HDDs and SSDs, and so on isn't yet clear. Our guess is that the very first products could be underwhelming, and will be held back by things like the controller technology and other specifics related to the early implementation. But, with any luck, we're no more than mere months away from revealing 3D XPoint's first tranche of secrets.

REBOOTING MOORE'S LAW

Is the end nigh for Moore's Law? You could certainly make that case. After all, it's true that the computer chip industry has had a tricky few years of late, keeping up with the pace of progress that Moore's Law implies.

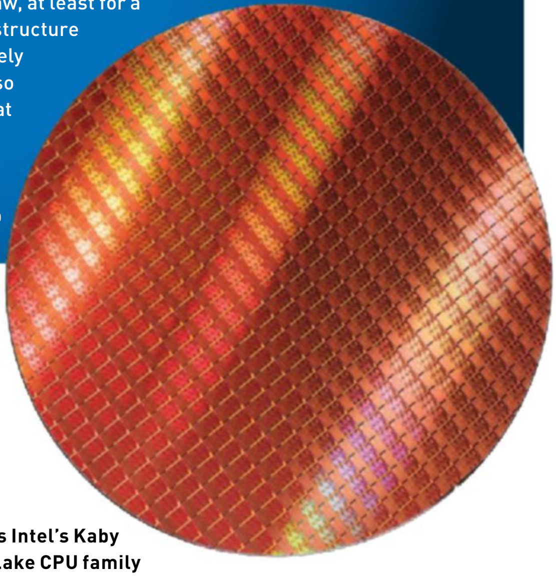
Lest you have forgotten, Moore's Law is simply the observation that transistor densities in integrated circuits tend to double every two years. Put another way, Moore's Law says computer chips either double in complexity and thus performance, or halve in cost—or some mix of the two, depending on what you're after—every couple of years.

It dates back to the 1960s or 1970s, depending on the precise part of the technological folklore you want to focus on. But the point is that it undeniably proved prescient for several decades. More recently, it's come into doubt. Whether Moore's Law has really hit a wall will only become clear several years from now. What we can say is that big players like Intel and TSMC—the latter being the foundry responsible for making most AMD and Nvidia GPUs in recent memory—have missed several self-imposed targets when it comes to new production nodes and shrinking their transistors.

The situation has become acute enough for Intel to abandon its so-called Tick-Tock cadence of a new CPU architecture and production process in alternating years, as dictated by Moore's Law. Instead, Intel has switched to a three-year cadence of process, architecture, and optimization.

Meanwhile, it's also undeniable that CPU operating frequencies have hit something of a wall around roughly 4GHz. In the good old days when MHz ruled, CPUs would benefit from both process shrinks and increased frequencies. Not any longer.

It's just possible, however, that 3D XPoint's chalcogenide underpinnings could reboot Moore's Law, at least for a time. The structure is completely different, so the fact that transistor gate sizes are running up against the laws of physics suddenly becomes irrelevant. 3D XPoint's chalcogenide devices don't use transistors. Likewise, chalcogenide devices have at least the theoretical potential to hit insanely high frequencies, well beyond those seen in commercial silicon chips. Whether any of this becomes a practical reality, only time will tell. But it's fun to know that it's possible we're on the cusp of a new wave of computing.



Is Intel's Kaby Lake CPU family the last of a dying breed of silicon chips?

unambiguously different position in the system hierarchy compared to existing solid-state drives. Overall, it points to a new class of memory that's difficult to currently define.

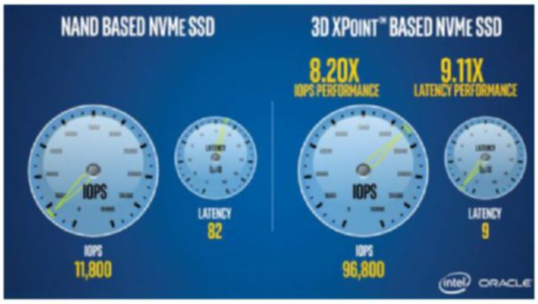
Even more significantly, however, could 3D XPoint be the basis of a new age of post-silicon computing? At this point, a warning is required. Much of what follows is highly speculative, though the scope for speculation is at least in part due to Intel and Micron's failure to provide clarity on some of the technical details.

Much of the speculation revolves around the materials and operational specifics of 3D XPoint. Some earlier speculation implied it depended on phase-change physics to store data, an approach that has been under evaluation for non-volatile memory for some time. Phase-change memory is built around a material known as chalcogenide glass, which sports some pretty funky properties. In simple terms, chalcogenide can be switched between amorphous and crystalline solid states or phases, courtesy of applying an electrical current. What's more, a number of distinct intermediate states can also be achieved. Amorphous versus crystalline gives you 0 and 1 for the storage of a single bit, obviously. The intermediate states allow for multiple bits of memory per cell.

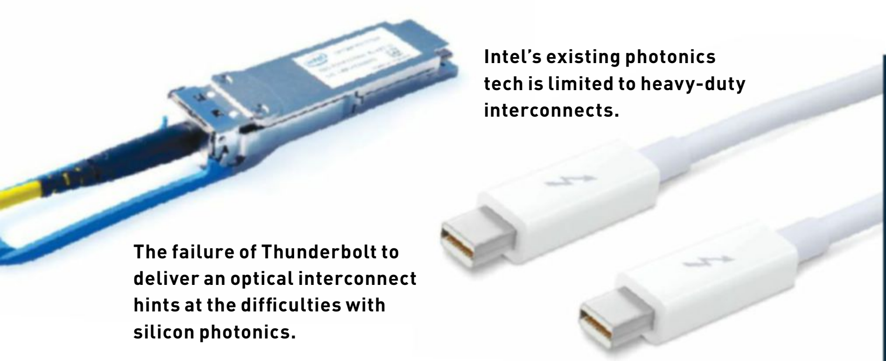
Multiple companies, including IBM, Samsung, Numonyx, and Intel, have been working on phase-change memory, or PRAM, for some time. However, Intel and Micron have repeatedly denied that 3D XPoint depends upon phase-change physics. For instance, when UK tech site The Register put the question to Micron regarding 3D XPoint's use of phase-change materials, it was told, "3D XPoint technology is a new class of non-volatile memory invented by Intel and Micron that relies on resistance change of the bulk material to achieve non-volatility. Unlike phase-change memory, 3D XPoint technology uses a unique cross point architecture, enabling it to scale in ways that phase-change memory has not been able to accomplish."

That's a pretty unambiguous denial that 3D XPoint is a phase-change memory technology. So, why are we even discussing it? How about this quote in reference to 3D XPoint, again from Guy Blalock of the IMFT? "Chalcogenide material and an Ovonyx switch are magic parts of this technology, with the original work starting back in the 1960s." So, 3D XPoint is a chalcogenide device, and builds on its development of that material in a computing context since the 1960s, which has been primarily centered on its phase-change properties. All very confusing.

This is where the conspiracy theories come in. Are Intel and Micron



Intel is certainly making impressive performance claims for its new Optane drives.



Intel's existing photonics tech is limited to heavy-duty interconnects.

The failure of Thunderbolt to deliver an optical interconnect hints at the difficulties with silicon photonics.

obscuring 3D XPoint's phase-change properties with a view to sidestepping patents they don't own? Could it be a double bluff, in which they imply that it's phase change by indicating that the core tech is chalcogenide, because they're either in the process of acquiring patents for something else, or know it can't be protected and want to give themselves as big a head start over the competition as possible? Who knows?

Where things get even more speculative is 3D XPoint's role as a candidate technology for non-memory devices. Some commentators speculate that transistor-less chalcogenide devices similar to those used in 3D XPoint memory cells are good candidates for replacing the transistor itself, and could operate at speeds far higher than silicon chips. Switching speeds measured in hundreds of gigahertz are mooted, and the simplicity of the internal structure could allow for additional scaling in device density, too. Put the two together, and you have a roadmap that keeps the computer industry rolling for some time, just when conventional silicon chips are increasingly running up against the laws of physics.

Another more specific avenue by which 3D XPoint might be implicated in new approaches to computing involves optical technology, or photonics—using light, rather than electrons, as the basis for computing. Photonics, of course, already exists as a computing technology, most obviously as a superfast data interconnect in the form of fiber optics. The fact that light is the ultimate in high-speed comms is a hint of its broader potential. Indeed, much of the backbone of the Internet, which is built out of fiber optics, depends on just that potential.

The argument as it relates to 3D XPoint, photonics, and computing goes something like this: Currently, integrating photonics into a computing platform requires dedicated chips. It's not possible to put silicon photonics on to the same chip as a high-performance computing circuit like a CPU. However, chalcogenide devices, according to some, solve that problem. Indeed, chalcogenide photonics is a science all of its own.

Taking the discussion any further, unfortunately, is almost impossible. We simply don't know whether Intel and Micron have plans beyond solid-state memory when it comes to 3D XPoint. It's true that the use of chalcogenide devices is extremely novel, but even the best qualified engineers and scientists can't say for sure where the limits lie for chalcogenide as a candidate material for replacing silicon and transistors.

If Intel and Micron have made some major breakthroughs, the only thing you can be sure about is that they'd be keeping their cards close to their chests until they were either certain they had the relevant intellectual property on total lockdown or, if that wasn't possible, until they were absolutely ready to launch products. The truth will out eventually. Watch this space. ⏻

There is speculation that transistor-less chalcogenide devices are candidates for replacing the transistor itself.

DOES 3D XPOINT SPELL DOOM FOR AMD?

By the time you read these very words, AMD could be back on roaring form. The first of its Ryzen CPUs have launched, and the early indications are that the new architecture is going to sock it straight to Intel with CPU models up to eight cores, and therefore give $1,000 Core i7 CPUs a run for their money at less than half the price.

Intel, of course, will hardly be blown out of the water. It's been taking things very easy in recent years, and has quite a bit of performance in hand. It can easily up its game, and no doubt will. But there's also a chance that 3D XPoint could give Intel a killer advantage, even without taking into account the more exotic end of the spectrum of possibilities that involve 3D XPoint-derived technology replacing CPUs wholesale.

Instead, we're talking about what's required to make the most of 3D XPoint as a memory and storage technology with conventional platforms and silicon processors. As we've seen, 3D XPoint has the potential to deliver a huge jump in solid-state storage performance. The benefit of that is obvious, but it's also theoretical. A storage technology that's 10 times faster than NAND simply has no way to talk to the CPU on existing platforms without either a huge performance hit or soaking up bandwidth that's critical for other components like graphics. That's the problem.

Instead, to make the most of 3D XPoint technology, new on-CPU interconnects and controllers will be needed. It goes without saying, Intel will be far, far better placed to design and implement them than AMD. It's not hard to imagine Intel shipping CPUs with on-package dollops of 3D XPoint memory measuring tens or hundreds of gigabytes, and offering stellar storage performance, thanks to clever caching features, for instance.

Maybe the solution will be along the lines of a new type of memory controller and data addressing, which can neatly speak to RAM and 3D XPoint memory in parallel, in some kind of shared memory space. Either way, at best AMD would be years behind, playing catch-up. If Intel can lock AMD out via patents or similar intellectual property restrictions, on the other hand, AMD could be out of the 3D XPoint game altogether, and with devastating consequences.

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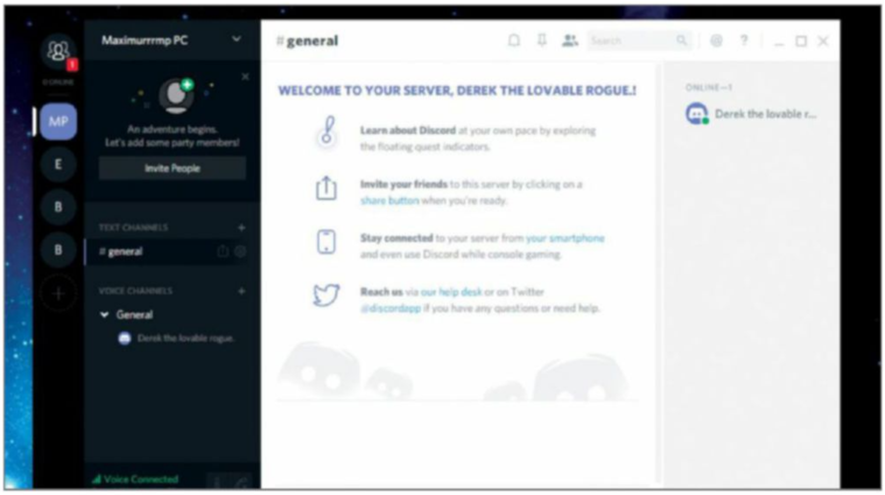
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



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MAKE – USE – CREATE

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70
Breathe life into old gear by building a PC from discarded parts

ZAK STOREY
REVIEWS EDITOR

DREAMING OF COPPER

I'm grateful—incredibly so—for what my job enables me to do. Working at *Maximum PC* is phenomenally good fun, and being in a position where I'm continuously surrounded by some of the most powerful hardware in the world allows me to build some amazing machines, the likes of which I used to only dream of.

That said, it does tend to mar my views on the world of hardware, with particular emphasis on what's "enough." I've had four separate systems this year, yet with each and every one, there have been niggling problems, whether it's fan noise, not enough processing power, or other irritating issues. My current S340 dual GTX 1080 is no different. This time, the problem lies with the GPUs. Frankly, it's only a small annoyance, but they tend to get a little toasty. Perhaps it's because I'm averse to running my intake fans any higher than 40 percent; or perhaps it's because there's just not enough airflow in the chassis.

Either way, I've come up with a solution, and it's another stab at water cooling. Yep, that means you're going to be getting at least one more feature this year on chilly liquid substance abuse, before we jump into the titanic attempt that is Dream Machine 2017. So, what will I be looking at this time around? Copper tubing, nickel plating, and one meaty-looking Phanteks Enthoo Evolv.

↘ submit your How To project idea to: comments@maximumpc.com

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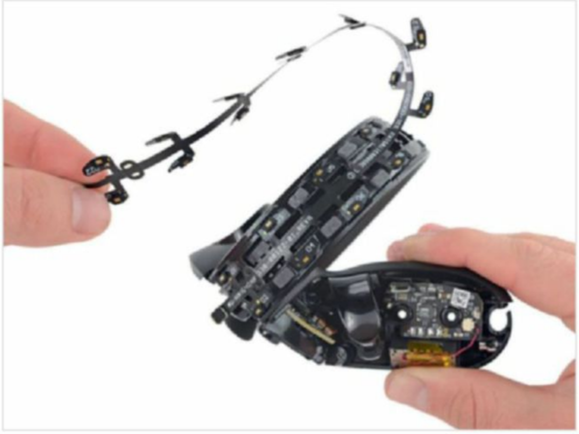
Oculus Touch

More torque screws than you could shake a VR controller at.

Hopefully, the LEDs will be easy to replace when damaged.



BACKGROUND

Oculus finally catches up with the big boys with the release of its ultra-responsive Oculus Touch controllers. Requiring a second IR camera and featuring a whole mess of tactile and capacitive input options, these controllers are bound to be chock-full of IR LEDs and tons of exciting tech—but we'll only know for sure if we tear them down!

MAJOR TECH SPECS

- An additional Oculus Sensor
- A Rockband adapter
- Two IR-emitting Touch controllers, with finger tracking and a mess of buttons

KEY FINDINGS

- Using our fancy IR-viewing technology, we get an Oculus Sensor's-eye view of the Touch controllers. While the twin black plastic halos are featureless to the naked eye, our camera sees the double rings of infrared LEDs residing beneath. The LEDs, like those present in the headset, are arranged in distinct patterns, allowing the Oculus Sensor to pick out the headset and two controllers, and determine their position and orientation. Also, thanks to the not-quite-round shape of each controller, the sensor ought to be able to tell left from right—even after you've crossed your arms while playing *Disappointed Parent Simulator 2016.*
- The battery panel is secured by a pretty hefty magnet, and packs a rubber bumper to keep the battery itself nicely in place. Said battery is a non-rechargeable but perfectly standard AA type, which you can replace with a rechargeable at the first opportunity. Better this than a glued-in battery!
- There are some hidden screws, but even after removing them, we're not getting anywhere. Looking around for another point of attack, we decide the top is as good a place as any. Smelling glue, we turn up the heat! Prying up the control surface reveals gobs of glue, and the cause of our troubles: another hidden screw.
- Uncovered, the single-cable LED array peels off fairly easily after being disconnected. All 22 IR LEDs are conveniently labeled, and there's even a barcode. Cross your fingers for Oculus-provided replacement parts! Digging deeper into the handheld's handle, we find a cute little power distribution board—that we can't remove without a soldering iron.
- Repairability Score: 5 out of 10 (10 is easiest to repair). Battery replacements are quick and easy, with a magnetic cover being the only barrier to entry. There are only T5 and T6 Torx screws in the Touch controllers, making screwdriver selection seamless. Accessing the Touch controller internals requires fighting through a layer of adhesive. The joystick, button bases, and battery connections are soldered to a board and require soldering knowledge to repair. Navigating through the tabs, adhesive, and hidden screws is not intuitive, and could result in damage during disassembly.

Secure Your Backups With nCrypted Cloud

YOU'LL NEED THIS

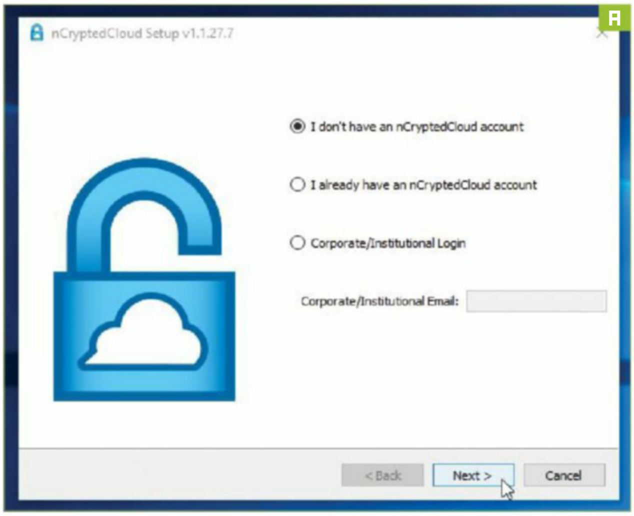
NCRYPTED CLOUD
The free account contains all the functionality you need.

SUPPORTED CLOUD ACCOUNT
nCrypted Cloud currently works with OneDrive, Dropbox, Box, Google Drive, and Egnyte.

EVER WONDERED JUST how secure your data is when you upload it to the cloud? Providers such as OneDrive and Dropbox make a big song and dance about the fact your data is encrypted, but who holds the all-important encryption keys? If those keys are stored with your data, as is the case with most cloud providers, it leaves one glaring weakness in your secure backup plan.

If you're serious about protecting your data, you need to add extra layers of encryption to it that aren't left in the hands of your cloud storage provider. nCrypted Cloud separates your encryption keys from your data, and one of those keys (the UPK—or User Personal Key) never leaves your client devices. Your cloud provider has no access to your key, and nCrypted Cloud has no physical access to your data, neatly closing that particular security loophole.

nCrypted Cloud works with all major cloud providers, and tucks in lots of useful tools and features to keep inconvenience down and security up. Read on to discover how to add a much-needed extra layer of security to your data. –**NICK PEERS**



● I don't have an nCryptedCloud account
○ I already have an nCryptedCloud account
○ Corporate/Institutional Login
Corporate/Institutional Email:

1 FIRST STEPS

Make sure you've installed the software for your chosen cloud service(s) before you set up nCrypted Cloud. It supports five major providers: Dropbox, Google Drive, OneDrive, Box, and Egnyte.

» Head over to www.encryptedcloud.com/apps, where you'll find a link for the Windows client. Click and save the installer to your hard drive, then double-click the setup file, and follow the prompts [**Image A**]. File Explorer will restart, so don't panic when the screen temporarily goes black. Once complete, leave "I don't have an nCrypted Cloud account" selected, and click "Next." Fill in the form, ignoring the prompt for a work email at the bottom. Remember to set a strong (but memorable—forget this and your data is toast) password, then check the terms of service box. Click "Next," and wait while a recovery key is generated. When prompted to enter your organization's name, click "Skip," followed by "Finish."

2 TWEAK INITIAL SETTINGS

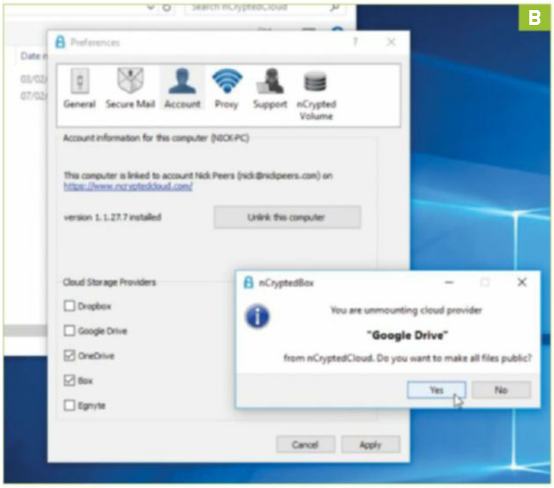
nCrypted Cloud scans your PC for any recognized cloud providers, and automatically links to them—you'll see a File Explorer window open, pointing to the nCrypted Cloud folder, inside which are shortcuts to each cloud provider. Don't panic—nCrypted Cloud hasn't started encrypting any files yet, so before you go further, review which providers have been linked, and verify you're happy with the choices made.

» If you want to exclude any, look in the Taskbar's Notification area for the nCrypted Cloud blue padlock-like icon. Right-click this, and choose "Preferences" to access the main "Settings" screen. Switch to the "Account" tab, where you'll see a list of providers [**Image B**]—simply deselect those you wish to exclude, and click "Apply." You're prompted to confirm each change by clicking "Yes," then entering your nCrypted Cloud's username and password.

3 ENCRYPT YOUR FIRST FOLDER

You're ready to add that extra layer of protection to your cloud-hosted data. To see how it works, enter your cloud folder in File Explorer, and locate a small folder. Right-click it, and choose "Make Private," clicking "Yes" when prompted. You'll see a progress bar as nCrypted Cloud encrypts the folder using AES 256-bit encryption, then the folder icon refreshes to show a blue padlock. This padlock is added to each file and subfolder inside the folder, too, making encrypted files easy to identify.

» Once complete, your cloud provider app should detect the change and upload the encrypted content to your cloud



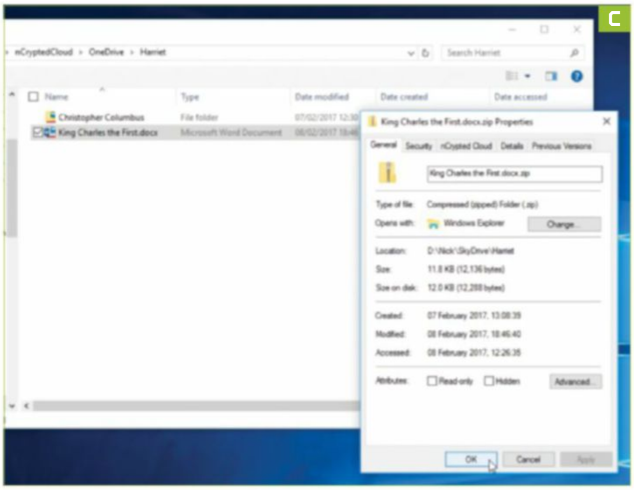
Account information for this computer (NICK-PC)

This computer is linked to account Nick Peers (nick@nickpeers.com) on https://www.ncryptedcloud.com/

version 1.1.27.7 installed

Cloud Storage Providers
☐ Dropbox
☐ Google Drive
☑ OneDrive
☑ Box
☐ Egnyte

You are unmounting cloud provider "Google Drive" from nCryptedCloud. Do you want to make all files public?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Name
Type
Date modified
Date created
Date accessed
Christopher Columbus
File folder
07/02/2017 12:30
King Charles the First.docx
Microsoft Word Document
08/02/2017 18:46
King Charles the First.docx.zip Properties
General
Security
nCrypted Cloud
Details
Previous Versions
Change...
Advanced...
OK
Cancel
Apply

King Charles the First.docx.zip

Type of file: Compressed (zipped) Folder (.zip)

Opens with: Windows Explorer

Location: D:\Nick\SkyDrive\Harriet

Size: 11.8 KB (12,136 bytes)

Size on disk: 12.0 KB (12,288 bytes)

Created: 07 February 2017, 13:08:39

Modified: 08 February 2017, 18:46:40

Accessed: 08 February 2017, 12:26:35

Attributes: ☐ Read-only ☐ Hidden

C

storage, overwriting the unprotected files. To verify this, right-click your cloud storage app's Taskbar Notification area icon, and choose "View online" (or similar) to access it through your web browser. Each file is now encrypted as a zip file, and is accompanied by an "nCrypted Cloud Readme" file. Click this to be told the folder has been protected, complete with a link to the nCrypted Cloud website. People can download the zip file, but they can't access its contents without the unique password assigned to it (see the box on right).

4 WORK WITH ENCRYPTED FILES

This confirms that the files are now protected by a second layer of encryption, so inaccessible to anyone even if they somehow gain access to your cloud provider account through the web. Look carefully at the file in File Explorer, however, and it appears to be unchanged. Double-click it, and it opens in the usual way. If you right-click an encrypted file and choose "Properties," however, you'll see it's now identified as a zip file (switch to the "nCrypted Cloud" tab and the file's actual properties are revealed, including its size) [Image C].

›› What's happening? The nCrypted Cloud app on your PC is invisibly decrypting any files you open, then encrypting them again once they're closed—including any saved changes. There's a slight pause with larger files, but otherwise the process is seamless.

5 LIMITATIONS

One major limitation of nCrypted Cloud is that some applications can't access your encrypted files from their traditional "Open" dialog boxes. Those that use the latest Windows "Open/Save" dialog box, which contains the same Navigation pane found in File Explorer, have no problems opening files, but older programs that use a different style of dialog—typically with a "Places" bar, listing five basic shortcuts—can't access files within protected folders; instead, they simply see the encrypted zip files (if they see anything at all).

›› To work around this problem, you need to open the file from within File Explorer— right-click, and choose"Open with..." to select your target app, if it isn't already the default for that file. Similarly, when you save files in these applications, they're saved without encryption—to fix this, right-click the file (or its parent folder, if there are a lot of files to process), and choose "nCrypted Cloud → Re-apply policy" (or "Make Private," if that option isn't present).

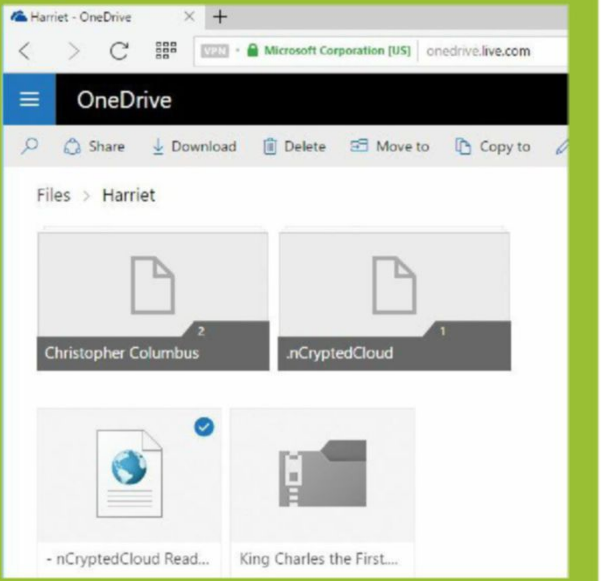
6 MORE ENCRYPTION OPTIONS

The "Make private" option can also be applied to individual files within your cloud folder when you right-click them [Image D]. Sadly, you can't select multiple files or folders at once to make them private—presumably for safety reasons—so you have to wade through your folders one at a time. Should you later wish to make files or folders publicly available again, right-click them as before, but this time choose "Remove Privacy," clicking "Yes" when prompted.

›› If you move a file from one folder to another within your cloud folder, you get a warning telling you the policy of the file will be changed to your name. This isn't important unless you've set up multiple identities, which is beyond the scope of this tutorial, so ignore it.

›› If you try to move or copy the file outside of your cloud folder by dragging it to another folder or drive, you end up transferring the encrypted zip file instead. Just drag it back into your cloud folder to make it accessible again. If

HOW DATA IS ENCRYPTED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Files › Harriet
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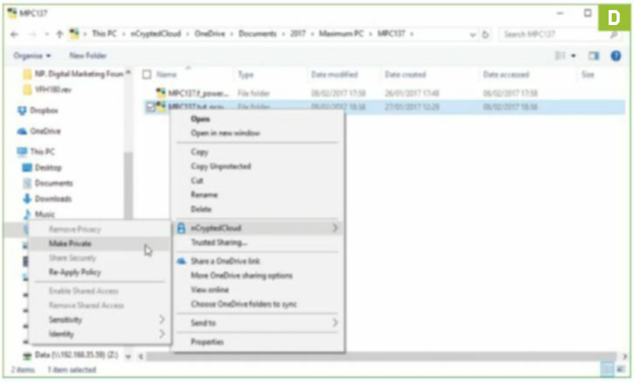
- nCryptedCloud Read...
King Charles the First....

nCrypted Cloud stores your data in compressed zip format, protected by industry standard AES-256 encryption. The universal nature of zip means there are plenty of tools—7-Zip (www.7-zip.org), for example—that can read, decrypt (with the right password), and extract the contents if necessary. The password in question isn't your nCrypted Cloud password; it's generated using nCrypted Cloud's own key management system.

This consists of two keys: UPK (User Personal Key) and URK (User Recovery Key). The UPK is generated using your account details, and never leaves your client. The URK is a public/private key, stored locally in a KeyStore file that's encrypted by Windows. This is transferred to the nCrypted Cloud server, but encrypted again before uploading.

URKs are generated for each file, and contain the unique password required for decrypting that file, which is found in the comment area of the zip file. This allows the file to be recovered using the Recovery Key (along with your user credentials). You can read a more detailed technical overview at https://bit.ly/ncrypted-encryption.


D
MPC137
This PC › nCryptedCloud › OneDrive › Documents › 2017 › Maximum PC › MPC137
Organize
New Folder
Name
Type
Date modified
Date created
Date accessed
Size
Open
Open in new window
Copy
Copy Unprotected
Cut
Rename
Delete
nCryptedCloud
Trusted Sharing...
Share a OneDrive link
More OneDrive sharing options
View online
Choose OneDrive folders to sync
Send to
Properties
Remove Privacy
Make Private
Share Securely
Re-Apply Policy
Enable Shared Access
Remove Shared Access
Sensitivity
Identity

you want to make an unencrypted copy of your target file or folder, right-click it in File Explorer, and choose "Copy Unprotected" to transfer it to the clipboard, then simply browse to your target folder, and press Ctrl-V to copy the unprotected file.

7

SET UP TRUSTED SHARING

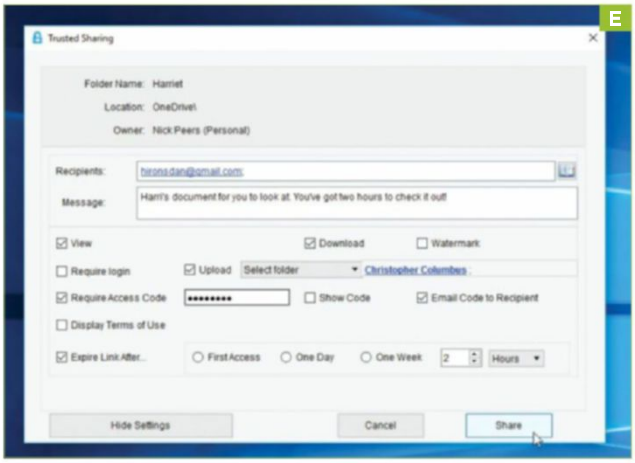
Like all good cloud providers, nCrypted Cloud makes it possible to share selected data with trusted users. Better still, they don't need to have their own cloud storage account or sign up for nCrypted Cloud. Simply right-click the file or folder you wish to share, and choose "Trusted Sharing." A new window appears. Type the email address of each person you want to share the folder or file with into the "Recipients" box (click the button to its right to use your Outlook address book). You can also add a suitably descriptive message to explain what's happening here, too.

» If necessary, click "Edit Settings" to fine-tune permissions. By default, your audience can only view the file or folder you send them. Select "Download" to allow them to download an unencrypted copy of the file on to their own computer, and select "Upload" if you'd like them to be able to make changes to some or any of the shared content (you select what after checking the box), and then upload the file back through their browser [**Image E**].

» You'll also see a "Watermarked" option—select this, and any shared files are watermarked with the recipients' email and IP addresses, discouraging any potential data leaks.

» For additional security, select "Require Access Code" so your recipients need to enter an additional alphanumeric password to gain access to the files. Select "Email Code to Recipient" to send a separate email containing the access code, or—if you're ultra-cautious—communicate it separately.

» You'll see the link is set to expire after one week—once this date passes, it won't work. You can change this so the link only works once, expires after a day, or choose "Other" to set an expiry time by minute, hour, day, or month. Once you're happy, click "Share."


E
Trusted Sharing
Hide Settings
Cancel
Share

Folder Name: Harriet
Location: OneDrive\
Owner: Nick Peers (Personal)
Recipients: hironsdan@gmail.com;
Message: Harri's document for you to look at. You've got two hours to check it out!
☑ View
☑ Download
☐ Watermark
☐ Require login
☑ Upload Select folder Christopher Columbus
☑ Require Access Code ••••••••• ☐ Show Code ☑ Email Code to Recipient
☐ Display Terms of Use
☑ Expire Link After... ○ First Access ○ One Day ○ One Week 2 Hours

8

HOW TRUSTED SHARING WORKS

Your recipient then receives one or two emails (the second containing the access code, if you opted to share it). Clicking "Access Share" takes them to a web page where—if necessary—they first need to enter the required access code. Once entered, they're shown the selected files or folders in the same Explorer-like interface you use when accessing nCrypted Cloud content through your own web browser.

» You're notified by email whenever anyone accesses the file, and if uploading is permitted, you're also alerted when someone either uploads new files or folders to the share, or makes changes and uploads edited copies of existing files to the nCrypted Cloud collaboration page (they can overwrite the original or opt to create a duplicate).

» To make changes to your share, log in to your account at https://login.ncryptedcloud.com, click the "Collaboration Management" icon, and go to "My Shares." Click the "Settings" button next to the shared folder, where you'll find options for revoking access, extending the expiry date, or tweaking the sharing settings.

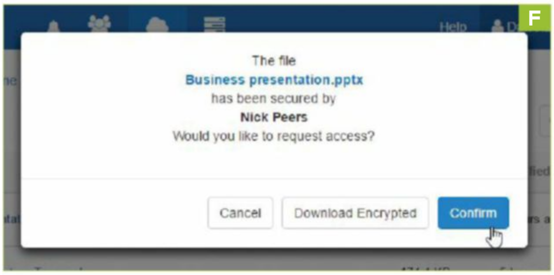
9

SHARED ACCESS

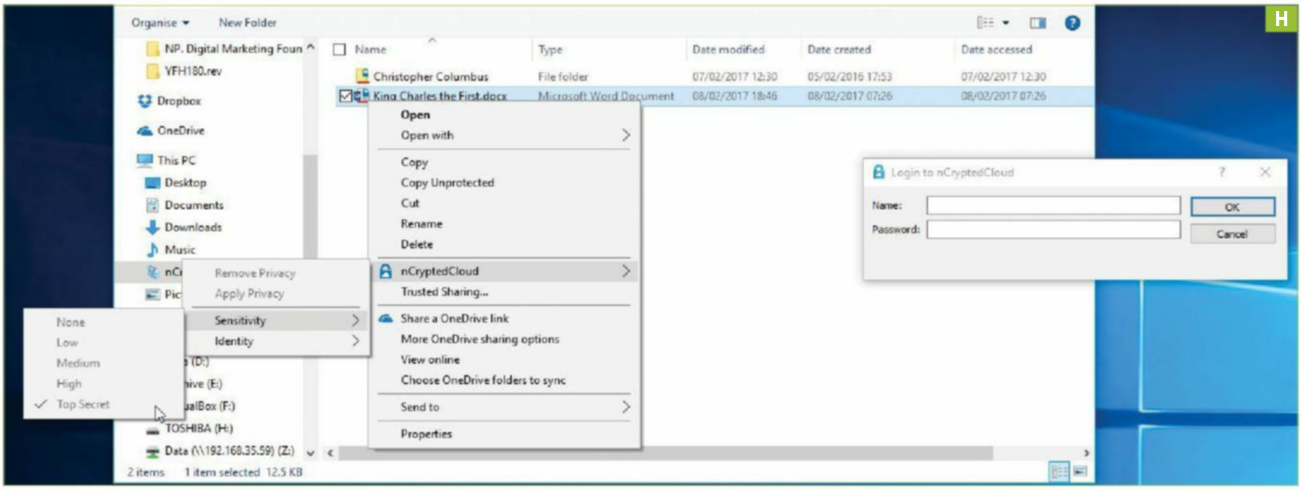
While Trusted Sharing is a good way to quickly share selected files and folders with anyone, if you plan to take collaboration to the next level, you and your confidants need their own Dropbox and nCrypted Cloud accounts (they obviously need to link both accounts together, too—go to "Preferences → Account" in nCrypted Cloud to do so). Once done, you can share a folder over the same cloud service without having to remove its encryption.

» If you'd like anyone you share the folder with to have access, right-click the folder in File Explorer, and first choose "Enable Shared Access" to set up open enrolment—this means anyone with an nCrypted Cloud account automatically gains access to the folder when you share it with them through their own nCrypted Cloud account. Don't select this if you want to review requests on a case-by-case basis.

» Finally, right-click the folder again, and choose the "Dropbox Share" option. Share the file in the usual way, and after your recipients accept the invitation in Dropbox, they can view the folder's contents normally in the nCrypted Cloud app, or online at the nCrypted Cloud web portal. If you skip open enrolment, when they attempt to open a file, they're prompted to either download the encrypted (and therefore unreadable) file, or ask for access [**Image F**]—you're prompted by email. Revoke access at any time by simply right-clicking the file or folder in File Explorer, and choosing "Remove Shared Access" to


F
Help
Cancel
Download Encrypted
Confirm

The file
Business presentation.pptx
has been secured by
Nick Peers
Would you like to request access?


H
Organise ▾
New Folder
NP. Digital Marketing Foun
YFH180.rev
Dropbox
OneDrive
This PC
Desktop
Documents
Downloads
Music
Remove Privacy
Apply Privacy
Sensitivity
Identity
None
Low
Medium
High
✓ Top Secret
TOSHIBA (H:)
Data (\\192.168.35.59) (Z:)
Open
Open with
Copy
Copy Unprotected
Cut
Rename
Delete
nCryptedCloud
Trusted Sharing...
Share a OneDrive link
More OneDrive sharing options
View online
Choose OneDrive folders to sync
Send to
Properties
Login to nCryptedCloud
Name:
Password:
OK
Cancel

Name	Type	Date modified	Date created	Date accessed
Christopher Columbus	File folder	07/02/2017 12:30	05/02/2016 17:53	07/02/2017 12:30
King Charles the First.docx	Microsoft Word Document	08/02/2017 18:46	08/02/2017 07:26	08/02/2017 07:26

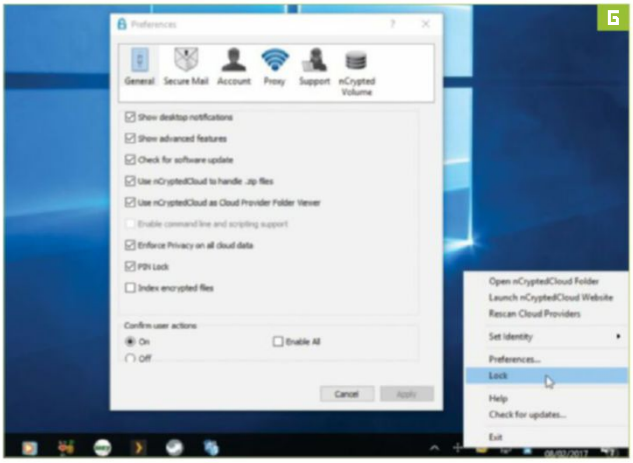
2 items 1 item selected 12.5 KB

remove everyone, or "Shared With…" to view and revoke access on an individual basis.

10 LOCK YOUR FILES

If you've got a PC or device in a shared location, you can lock your encrypted files when you're not at your desk. First log into your account at https://login.ncryptedcloud.com, then browse to "Settings → Personal PIN." Set a numerical PIN code (the longer, the more secure, obviously), and click "Update." Exit and restart nCrypted Cloud on your PC, then right-click its Taskbar Notification area icon, and choose "Preferences." You'll now see that "PIN Lock" is no longer grayed out [**Image G**]—select this, enter your PIN code, and click "Apply."

» Right-click the nCrypted Cloud Taskbar Notification area icon again, and you'll see a new "Lock" option. Select this, and your protected storage folders—encrypted or otherwise—are all off-limits. Right-click the icon again, and choose "Unlock," followed by your PIN, to make them accessible again. When "PIN Lock" is enabled, you are also prompted to enter your PIN whenever you start your PC.


G
Preferences
General
Secure Mail
Account
Proxy
Support
nCrypted Volume
Cancel
Apply
Open nCryptedCloud Folder
Launch nCryptedCloud Website
Rescan Cloud Providers
Set Identity
Preferences...
Lock
Help
Check for updates...
Exit

☑ Show desktop notifications
☑ Show advanced features
☑ Check for software update
☑ Use nCryptedCloud to handle .zip files
☑ Use nCryptedCloud as Cloud Provider Folder Viewer
☐ Enable command line and scripting support
☑ Enforce Privacy on all cloud data
☑ PIN Lock
☐ Index encrypted files

Confirm user actions
● On
○ Off
☐ Enable All

11 PROTECT SENSITIVE FILES

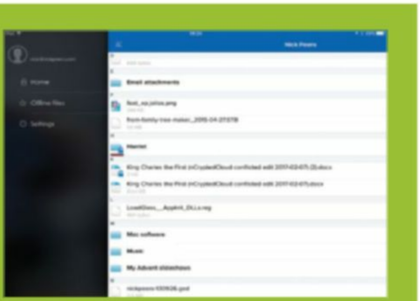
Last, but not least, want to apply additional protection to individual files or folders? Right-click the nCrypted Cloud Taskbar Notification area icon, and choose "Preferences." Check the "Show advanced features" box on the "General" tab, then click "Apply." When you next right-click an item and open the nCrypted Cloud submenu, you'll see a new "Sensitivity" menu, offering five choices. Select one, and the item is color-coded accordingly, from green (Low) through yellow (Medium), orange (High), and finally red (Top Secret). Select "none" to remove any sensitivity setting.

» This is fine, but how does it better protect your files? Simple: If you mark an item "Top Secret," you're prompted to enter your nCrypted Cloud account credentials each time you access it through the app [**Image H**], providing another welcome layer of protection. ⏻

ACCESS FROM OTHER DEVICES

It's unlikely that you're happy being able to access your data from just your PC. One way to temporarily access your files from any device is through a secure web browser—go to https://login.ncryptedcloud.com and log in. You can browse your entire cloud storage and access your encrypted files and folders without having to worry about them. Click a file to view it in your browser, or click the "…" next to it for more options, including downloading the file in its original, non-protected form. Better still, you can download and install the nCrypted Cloud app on Windows and Mac, enabling you to access your data seamlessly on other desktops and laptops. You can also install the nCrypted Cloud app on your iOS or Android device—search the relevant app store for "ncrypted" (select the newer Pro version if it's available)—and use that to access your data on the move.

Worried about unauthorized access? Every time you connect a new device, you receive an email notification. You can manage connected devices from your account page at https://login.ncryptedcloud.com—go to "Settings → Devices'" to review currently connected apps. Click "Unlink" next to any to immediately revoke its access.



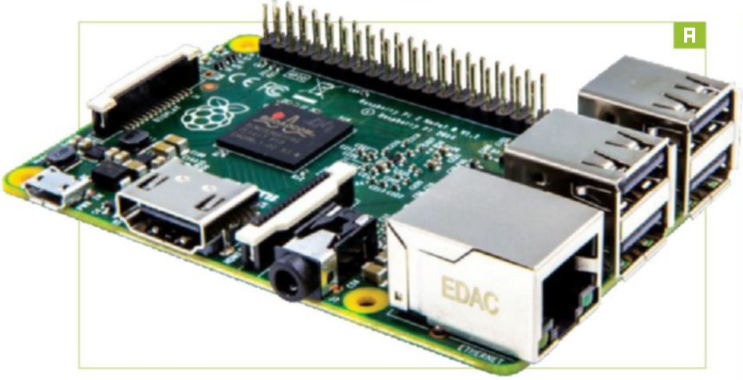
Protect Yourself With a Pi-Based Firewall

YOU'LL NEED THIS

RASPBERRY PI
The brilliant mini-computer costs under $50. See www.raspberrypi.org.

YOU PROBABLY REMEMBER THE NEWS. In December 2016, it was reported that the infamous Mirai worm had infected a substantial number of routers used by customers of UK ISP TalkTalk, stealing their Wi-Fi passwords. The worm exploited the default admin passwords that are hardwired into a number of machines, and although the focus was on enslaving devices to take part in DOS (Denial of Service) attacks, the implications are staggering. Even those handfuls of users who take the trouble to change their router's default passwords seldom bother to use firewalls.

In plain English, this means your router's settings, and theoretically devices on your home wireless network, could be laid bare by attackers. Fortunately, the Raspberry Pi comes to the rescue once again, and we'll show you how. **–NATE DRAKE**



1 YOUR OBJECTIVES

This project can be roughly divided into two parts. The first is to set up your Raspberry Pi [**Image A**] as a wireless AP (access point). In other words, the Pi will create a wireless network for you to connect to. The Pi can then be connected to your router, so that anyone connected to its wireless network can access the Internet.

» The second part of this project involves installing an easy-to-use firewall on your Raspberry Pi, which will block any open ports that attackers can exploit. You can also configure the firewall to allow access to legitimate programs, as well as block any websites you think are unsafe. Provided you have the correct equipment, you can have your own secure AP with firewall up and running in under 20 minutes.

2 THE BARE NECESSITIES

The wireless device you use must be compatible with Hostapd (more about this shortly). This project is technically compatible with all models of Pi, although the Pi needs to be both wireless-enabled and have an Ethernet port to connect to your router. The Raspberry Pi 3 lends itself very well to this. If at all possible, setup should be done using a keyboard and monitor, rather than SSH, as once the Pi has created its own AP, you won't be able to connect to it wirelessly. You can, however, connect to it through your router's wireless network, if you know the IP address.

» If you prefer the compact Pi Zero [**Image B**], make sure you have both a USB OTG host cable or a USB to micro-USB OTG adapter (available from all Pi accessory suppliers—from Adafruit, for example, it's just $3, www.adafruit.com/product/2910). You also need an RJ45 to USB converter to attach to the USB port. You can then connect the Pi Zero to your router. In addition to the Raspberry Pi itself, you also need a secondary device to check that the wireless AP is functioning correctly, as well as a network cable to link the Pi to the router. Most modern routers have at least one USB port, so you should be able to power the Pi from there.

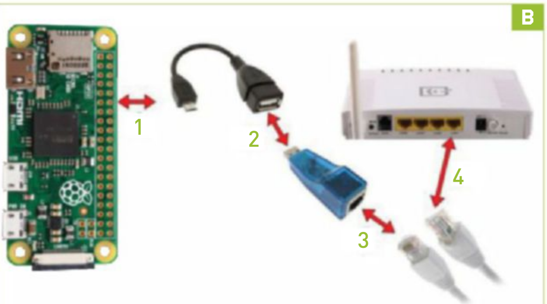
» For security reasons and to save on resources, it's best to have a dedicated Raspberry Pi for your home firewall [**Image C**], rather than one that you might use for other additional purposes. If at all possible, plug your Pi into a monitor, and work from Terminal directly when going through this project, rather than connect via SSH. This reduces the chance that your connection will drop at a vital stage in the proceedings.

» As always, it's best to start with a clean install of the latest version of Raspbian on the Pi. Once the install is complete, open Terminal, and run the following commands to be certain your system is fully up to date:

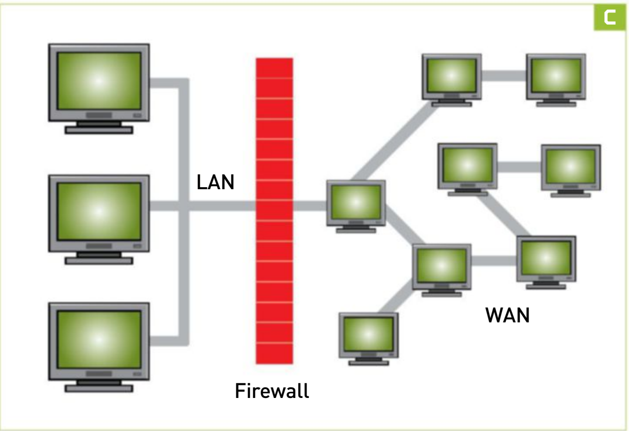
```
sudo apt-get update
sudo apt-get upgrade
```

» If you do not have access to a monitor, you can connect to the Pi wirelessly through your router's Wi-Fi network via SSH. Connect your Pi to the router via Ethernet cable first. If you have a mobile device, the handy app Fing can be used to easily identify the IP address of all devices on your local network. Fing is available to download free of charge from both the iOS App Store and Google Play.

» Once you're satisfied that the AP is working as you would like, be sure to disable the wireless function on your router, to prevent people from connecting to it instead of the Raspberry Pi firewall.



Serving suggestion for Pi Zero Internet connection. The OTG cable (2) allows connection of regular USB devices. The RJ45 converter (3) allows connection via Ethernet.



3

TALKING POINTS

The access point is set up and managed by the handy program Hostapd. Step three of our walkthrough over the page covers creating a configuration file wherein you specify the settings for the Pi's new wireless network, such as name, password, and encryption type used. You can return to this hostapd.conf file at any time to change your settings if you wish.

» While every wireless card can connect you to a Wi-Fi network, not all Wi-Fi cards can generate their own wireless networks. Fortunately, the Wi-Fi module built into the Raspberry Pi 3 does support this feature, which is a good reason to consider using one for your firewall.

» We'll also install the devilishly clever program Dnsmasq to handle the network infrastructure. It also draws its settings from a small configuration file, which you set up in step four. The suggested settings have Dnsmasq use Google for its DNS server (8.8.8.8), but you can change this to another DNS provider if you wish, such as OpenDNS (208.67.222.222). For best performance, you may want to list more than one DNS server. To do this, simply add a new line for this in the dnsmasq.conf file, for example:

```
server=208.67.222.222
server=208.67.222.220
```

4

UNCOMPLICATED FIREWALL

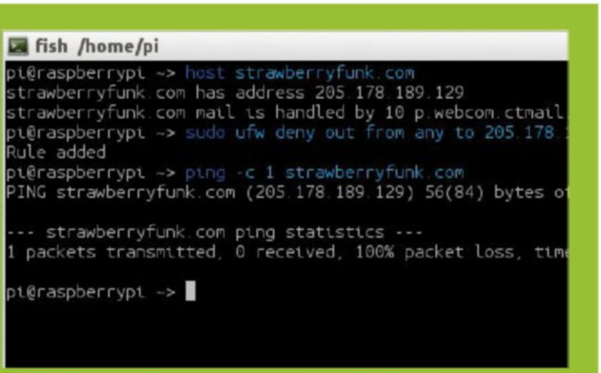
Ufw (Uncomplicated Firewall) comes bundled with a number of Linux distros and, true to its name, is very simple to use. It is by no means the only firewall program out there—in fact, there are entire distributions of Linux in the wild, such as IPFire (more on this next month), which are specifically designed to act as a gateway between your computer and the Internet, complete with colorful windows. Why, then, use a rather mundane command-line application? Aside from the fact that Ufw has withstood the test of time, it's very easy to install and set up. Once enabled, it launches automatically. By default, it blocks all incoming connections, and allows all outward ones. This can be a nuisance if you and other users on your network want to use certain applications, such as BitTorrent or Skype, but configuring exceptions to these rules is easy. Ufw also has a graphical companion for those who are still not entirely comfortable with the command line. See the "Configuring your Firewall" boxout on page 65.

» Ufw also has the ability to block connections to specific IP addresses or ranges, so you can prevent network users from visiting certain websites (see "Domain Denial," above-right).

» Although Ufw can be used to block individual websites, any web pages that do load display banner ads and pop-ups. By far the easiest way to deal with these irritations is for you and other users on your network to install browser extensions, such as Ublock Origin and Ghostery, to prevent both ads and tracking cookies. Mobile users can also benefit from the official Adblock Browser.

» If this isn't feasible, you can remove the Raspberry Pi's default DHCP (Dynamic Host Configuration Protocol) server, and configure Dnsmasq in its place to automatically redirect known ad servers to an internal IP address. By default, this creates ugly blank spaces in the middle of your web pages, but you can solve this by also installing the handy app Pixelserv. Pixelserv's sole purpose in life is to support ad-blocking via serving a transparent 1x1-pixel GIF image in place of ads. This makes your ad-blocking a much tidier experience.

» If you're interested in adding an ad-blocking feature to the Raspberry Pi, a tutorial is available on the Adafruit website: https://learn.adafruit.com/raspberry-pi-as-an-ad-blocking-access-point.



```
pi@raspberrypi ~> host strawberryfunk.com
strawberryfunk.com has address 205.178.189.129
strawberryfunk.com mail is handled by 10 p.webcom.ctmail
pi@raspberrypi ~> sudo ufw deny out from any to 205.178.
Rule added
pi@raspberrypi ~> ping -c 1 strawberryfunk.com
PING strawberryfunk.com (205.178.189.129) 56(84) bytes o

--- strawberryfunk.com ping statistics ---
1 packets transmitted, 0 received, 100% packet loss, tim

pi@raspberrypi ~> 
```

DOMAIN DENIAL

Its full name, Uncomplicated Firewall, might sound modest, but Ufw is a powerful firewall, and can be used to block access to certain websites. Although, technically, you can also do this with Dnsmasq, this would be a form of "DNS hijacking," which is a rather dastardly procedure, usually carried out by scammers.

The advantage of using Ufw is that it blocks domains by IP address. This means you have to write down only one rule per address, rather than remember the various domains and subdomains used by sites. Imagine trying to block every variant of Facebook.com, for instance: fb.com, m.facebook.com, the list goes on.

It stands to reason, then, that in order to block websites by IP address, you need that information. Open Terminal on your Pi, or connect via SSH, and use the `host` command to view an objectionable page's IP address. For instance:

```
host strawberryfunk.com
```

This outputs the IP address of the site in question. Next, use `ufw deny` to block this domain. For example:

```
sudo ufw deny out from any to 205.178.189.29
```

You can check that the domain has successfully been blocked by using `ping`. For example:

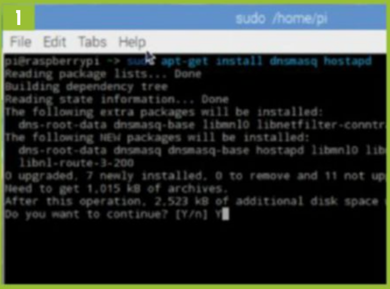
```
ping -c 1 strawberryfunk.com
```

If you have set up Ufw correctly, ping reports that the domain is unreachable.

Ufw can also block outgoing connections to certain ports. For instance, if you want to reduce the chance of your Pi being used to send spam messages, you can disable Port 25 with the following:

```
sudo ufw deny out 25
```

CREATE YOUR FIREWALL WITH UFW



```
pi@raspberrypi -> sudo apt-get install dnsmasq hostapd
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following extra packages will be installed:
  dns-root-data dnsmasq-base libmnl0 libnetfilter-conntr
The following NEW packages will be installed:
  dns-root-data dnsmasq dnsmasq-base hostapd libmnl0 lib
  libnl-route-3-200
0 upgraded, 7 newly installed, 0 to remove and 11 not up
Need to get 1,015 kB of archives.
After this operation, 2,523 kB of additional disk space
Do you want to continue? [Y/n] Y
```

1. INSTALL PREREQUISITES

Plug your Raspberry Pi into the Ethernet port on your router, then connect via SSH, or ideally open Terminal on the Pi. Install the necessary programs by running:

```
sudo apt-get install dnsmasq hostapd
```

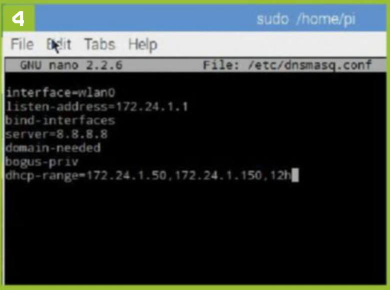
Next, run the following to open the configuration file:

```
sudo nano /etc/dhcpcd.conf
```

Now add these lines to the very bottom of the file:

```
interface wlan0
static ip_address=172.24.1.1/24
```

Press Ctrl-X, Y, then Return to save the file and exit.



```
  GNU nano 2.2.6                File: /etc/dnsmasq.conf

interface=wlan0
listen-address=172.24.1.1
bind-interfaces
server=8.8.8.8
domain-needed
bogus-priv
dhcp-range=172.24.1.50,172.24.1.150,12h
```

4. CONFIGURE DNSMASQ

Move the old Dnsmasq configuration file with:

```
sudo mv /etc/dnsmasq.conf /etc/dnsmasq.conf.orig
```

Then create a new one by running:

```
sudo nano /etc/dnsmasq.conf
```

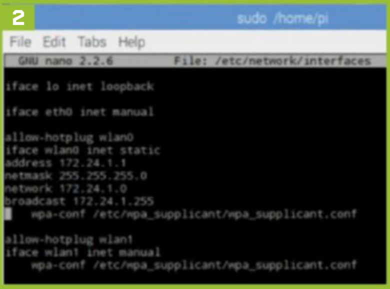
Enter in the following text:

```
interface=wlan0
listen-address=172.24.1.1
bind-interfaces     things elsewhere
server=8.8.8.8
domain-needed
bogus-priv
dhcp-range=172.24.1.50,172.24.1.150,
12h
```

Save and exit. Now run:

```
sudo nano /etc/sysctl.conf
```

Find the line starting "net.ipv4.ip_forward=1" and remove the # at the start. Save, exit, and reboot the Pi.



```
  GNU nano 2.2.6           File: /etc/network/interfaces

iface lo inet loopback

iface eth0 inet manual

allow-hotplug wlan0
iface wlan0 inet static
address 172.24.1.1
netmask 255.255.255.0
network 172.24.1.0
broadcast 172.24.1.255
    wpa-conf /etc/wpa_supplicant/wpa_supplicant.conf

allow-hotplug wlan1
iface wlan1 inet manual
    wpa-conf /etc/wpa_supplicant/wpa_supplicant.conf
```

2. SET STATIC IP

Open your network interfaces configuration with:

```
sudo nano /etc/network/interfaces
```

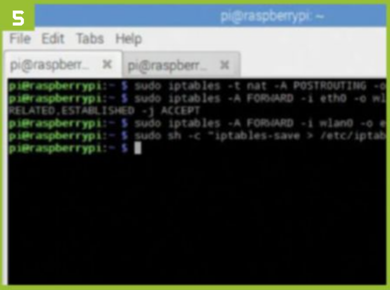
Find the line "iface wlan0 inet static" and change it to:

```
iface wlan0 inet manual
```

Press Return to start a new line, then enter the following:

```
address 172.24.1.1
netmask 255.255.255.0
network 172.24.1.0
broadcast 172.24.1.255
```

Place a # at the start of the line beginning "wpa-conf." Save and exit in the same way as before.



```
pi@raspberrypi:~ $ sudo iptables -t nat -A POSTROUTING -o
pi@raspberrypi:~ $ sudo iptables -A FORWARD -i eth0 -o wl
RELATED,ESTABLISHED -j ACCEPT
pi@raspberrypi:~ $ sudo iptables -A FORWARD -i wlan0 -o e
pi@raspberrypi:~ $ sudo sh -c "iptables-save > /etc/iptab
pi@raspberrypi:~ $
```

5. SET UP IPV4 FORWARDING

Open Terminal on your Pi and run:

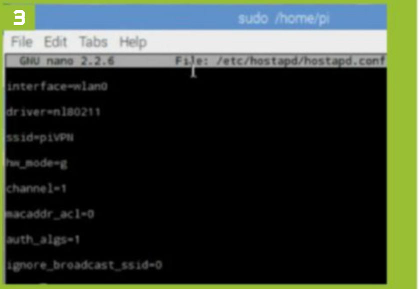
```
sudo iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE
sudo iptables -A FORWARD -i th0 -o wlan0 -m state --state RELATED,ESTABLISHED -j ACCEPT
sudo iptables -A FORWARD -i wlan0 -o eth0 -j ACCEPT
sudo sh -c "iptables-save > /etc/iptables.ipv4.nat"
```

Next, run:

```
sudo nano /etc/rc.local
```

Type the following two lines just above the line reading "exit 0:"

```
iptables-restore < /etc/iptables.ipv4.nat
/usr/sbin/hostapd /etc/hostapd/hostapd.conf
```



```
  GNU nano 2.2.6           File: /etc/hostapd/hostapd.conf

interface=wlan0

driver=nl80211

ssid=piVPN

hw_mode=g

channel=1

macaddr_acl=0

auth_algs=1

ignore_broadcast_ssid=0
```

3. SET UP ACCESS POINT

Open the hostapd.conf file by running

```
sudo nano /etc/hostapd/hostapd.conf
```

Type the following:

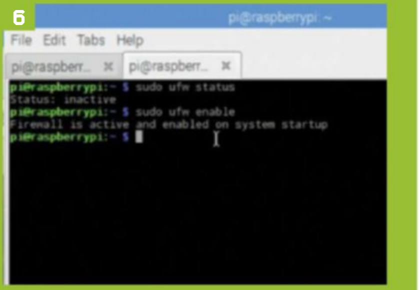
```
interface=wlan0
driver=nl80211
ssid=piVPN
hw_mode=g
channel=1
macaddr_acl=0
auth_algs=1
ignore_broadcast_ssid=0
wpa=2
wpa_key_mgmt=WPA-PSK
wpa_passphrase=raspberry231
wpa_pairwise=TKIP
rsn_pairwise=CCMP
```

Change the SSID, passphrase, and network encryption as you see fit. Next run:

```
sudo nano /etc/default/hostapd
```

Find the line starting "#DAEMON_CONF=""." Remove the # at the start of the line and change it to:

```
DAEMON_CONF="/etc/hostapd/hostapd.conf"
```



```
pi@raspberrypi:~ $ sudo ufw status
Status: inactive
pi@raspberrypi:~ $ sudo ufw enable
Firewall is active and enabled on system startup
pi@raspberrypi:~ $
```

6. SET UP FIREWALL

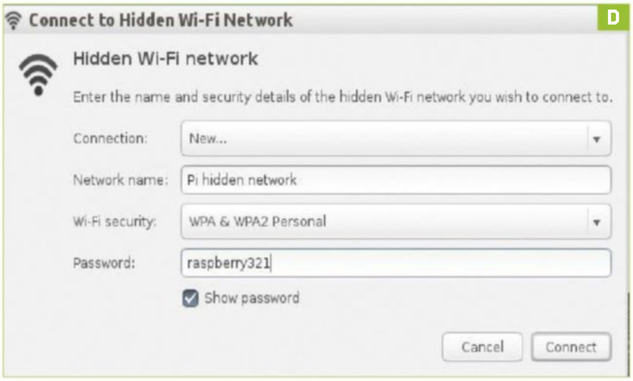
Run the following commands, one after the other:

```
sudo update-rc.d hostapd enable
sudo update-rc.d dnsmasq enable
```

Reboot the Pi, and reopen Terminal. To install and then enable the firewall, run the following:

```
sudo apt-get install ufw gufw
sudo ufw enable
```

You may wish to configure the firewall at this stage—see "Configuring your Firewall" on the opposite page.



Connect to Hidden Wi-Fi Network

Hidden Wi-Fi network

Enter the name and security details of the hidden Wi-Fi network you wish to connect to.

Connection: New...
Network name: Pi hidden network
Wi-Fi security: WPA & WPA2 Personal
Password: raspberry321
☑ Show password

5 BUILDING BRIDGES

This project focuses on bridging the connection between your Pi's wireless interface and the Ethernet interface. This allows your access point to remain connected to the Internet. If you need to double-check the names of your interfaces, you can run the command `ifconfig` at any time. By default, the names of these interfaces should be "wlan0" and "eth0" respectively.

›› If you're unable to plug the Pi into a router, theoretically you could add another wireless interface, such as the official Raspberry Pi Wi-Fi module, and use it to access your router's wireless network. However, this is less secure, and reduces your connection speed. If your router is somewhere hard to reach (or actually out of range), consider using a "homeplug" style device, which uses the power lines in your home or office for network connections.

›› Do not despair if the access point or the firewall do not work the first time you go through the steps. Fortunately, the Pi's network settings are very flexible, so you can usually go back over the steps again without having to reinstall Raspbian.

›› If you're using a Wi-Fi driver besides that built into the Pi 3 or the official Raspberry Pi Wi-Fi adapter, you may have to change the "driver=" value in hostapd.conf. For information, visit http://linuxwireless.org/en/users/Documentation/hostapd.

›› You can disable the Ufw firewall permanently and delete all rules with the following command:

```
sudo ufw reset
```

›› If required, you can also restore the settings you previously backed up with Dnsmasq, by reversing the original command:

```
sudo mv /etc/dnsmasq.conf.orig /etc/dnsmasq.conf
```

›› If you choose to block specific ports or services (see the "Domain Denial" boxout on page 63), bear in mind that IT-literate users on your network could bypass this via a VPN. You can, of course, use Ufw to block the ports commonly used by VPNs, such as 1154, or block all outgoing traffic, and then enable it for specific applications and services. Some applications randomize the ports used, making it difficult to lock down specific protocols, such as BitTorrent. You might consider disabling UDP (User Datagram Protocol) if you want to prevent streaming of most music and video sites.

›› If you choose to use a browser extension or Pixelserv to block ads, certain sites may display incorrectly or fail to load altogether. Ad-blocking extensions can usually be disabled temporarily by clicking on their icon in your browser's menu bar.

For security reasons, it would be wise to use a dedicated Pi exclusively as an access point, and avoid placing any personal data on it. For extra safety, be sure to use a long, robust password—the one in the tutorial is only by way of example.

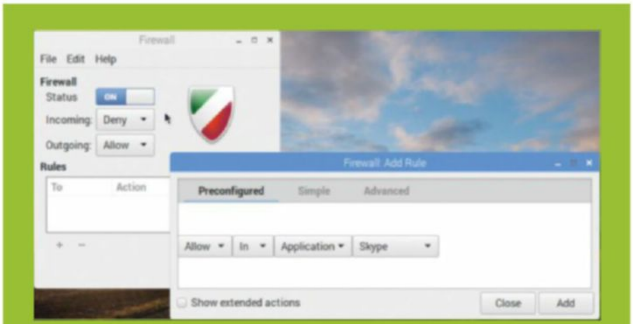
›› For the uber-cautious, consider creating a hidden Wi-Fi network for the Pi [**Image D**]. Edit the Hostapd configuration by opening a Terminal and typing:

```
/etc/hostapd/hostapd.conf
```

Change "ignore_broadcast_ssid=0" to "ignore_broadcast_ssid=1." From now on, all devices will have to enter the name of the network as well as the password in order to connect. Consider setting a new name when editing the file to be extra secure.

›› If you have devices using a cabled connection, such as a home server, you can continue connecting these directly to your router for Internet access, but bear in mind that they won't be visible on the Pi's wireless network. This works both ways, however—the Pi will not interfere with their operations at all.

›› Finally, bear in mind that your router may also use a firewall. If you're comfortable with configuring your router, you can choose to open and close ports to match Ufw's settings. Alternatively, you can disable the router's firewall altogether, and let the Pi manage everything. ⏻



Firewall
Status: ON
Incoming: Deny
Outgoing: Allow

Allow In Application Skype
☐ Show extended actions

CONFIGURING YOUR FIREWALL

Once enabled, Ufw automatically launches on startup, blocking all incoming connections, and allowing all outgoing ones. This might not be the ideal setup for you, particularly if you like to connect to your Pi via SSH or VNC. To configure Ufw, use Terminal on your Pi. Ufw recognizes most services like SSH, so in most cases you can enable access using `ufw allow`. For instance:

```
sudo ufw allow ssh
```

To see a full list of services you can enable in this way, simply run the following command:

```
nano /etc/services
```

If your service isn't listed, you can simply open the port it uses. For instance, RealVNC, which can be used to connect remotely to the Pi's desktop, runs on Port 5800. To have Ufw open it, run:

```
sudo ufw allow 5800
```

To allow connections only from a specific IP address, use `from`. For instance:

```
sudo ufw allow from 192.168.1.12
```

For a complete readout of the firewall settings in Ubuntu, use the following:

```
sudo ufw status verbose
```

To make life even easier for you, Ufw has a graphical companion, Gufw. To open it, run:

```
sudo gufw
```

There's a handy rocker switch, as well as a list of open and blocked ports. Click the "+" button to add additional rules. Click "Show extended actions" to see preconfigured settings for certain popular applications, such as Skype.

The Last Password You'll Ever Need

YOU'LL NEED THIS

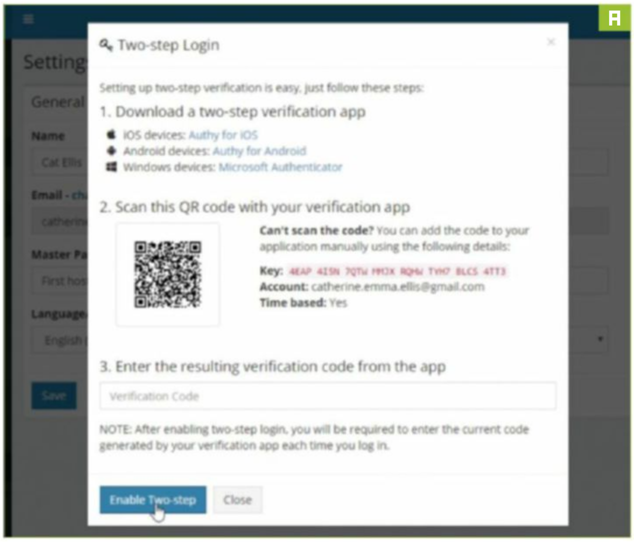
BITWARDEN
Head to https://bitwarden.com.

SOMETHING TO PROTECT
An Internet-connected PC and smartphone.

WE ALL KNOW WE SHOULDN'T RE-USE PASSWORDS, but with so many websites requiring user accounts, creating a different, secure, memorable login for each is all but impossible. That's before you consider how you're going to change them regularly (a policy enforced by some companies).

This leads to an problem: If someone can crack the password for one of your accounts, it can open the door to many others. That's where password managers come in, storing all your account details in a central location, and automatically completing login screens so you don't have to remember them yourself (or jot them down on sticky notes). The password vault is secured by a single master password, which is the only one you need to commit to memory.

Bitwarden is a free, open-source password manager that stores your account details in the cloud, enabling you to access them from any Internet-enabled device. Bitwarden encrypts everything using AES 256-bit encryption and salted hashing, so the data on its servers is no use without your master password—and your smartphone, if you enable two-factor authentication. Because Bitwarden is cloud-based, it can't be used to secure passwords for Wi-Fi access points, Windows user accounts, or other offline services, but for web accounts, it's excellent. –**CAT ELLIS**



Two-step Login

Setting up two-step verification is easy, just follow these steps:

1. Download a two-step verification app
- iOS devices: Authy for iOS
- Android devices: Authy for Android
- Windows devices: Microsoft Authenticator

2. Scan this QR code with your verification app

Can't scan the code? You can add the code to your application manually using the following details:

Key: 4EAP 4I5N 7QTW MM3X RQHW TVH7 BLCS 4TT3
Account: catherine.emma.ellis@gmail.com
Time based: Yes

3. Enter the resulting verification code from the app

Verification Code

NOTE: After enabling two-step login, you will be required to enter the current code generated by your verification app each time you log in.

1 CREATE ACCOUNT AND ENABLE TWO-STEP VERIFICATION

Visit https://bitwarden.com and select "Create an account." The master password that you enter here will be the only way to access your encrypted logins in the future, so make sure it's memorable, and add a hint that only makes sense to you. Once you've finished, log in.

›› It's a good idea to initiate two-factor authentication so that even if your master password is compromised, your logins can't be decrypted without verification from your smartphone. Click "Settings → Two-step login." Enter your master password again, then download the appropriate mobile app (Authy for iOS or Android, or Microsoft Authenticator for Windows devices), and follow the on-screen instructions to create an authentication account. Use the smartphone app to scan the QR code on your Bitwarden account page [**Image A**] to connect the two accounts. Now, to log into Bitwarden, you'll need not only your master password, but also a seven-digit security token generated by the mobile app every 20 seconds. Bitwarden provides you with a backup code in case you lose your phone; keep this in a safe place.

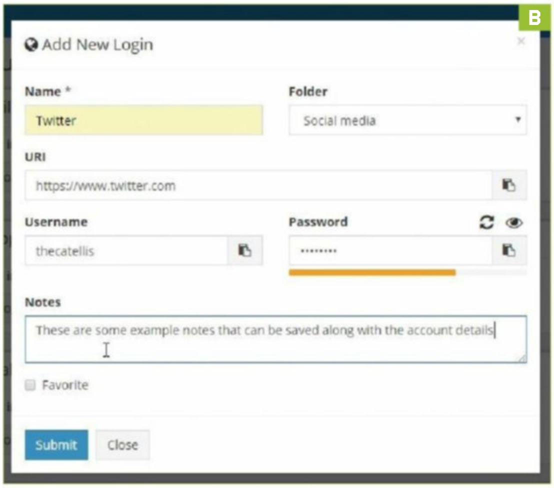
2 STORE YOUR LOGINS

Now you're ready to start saving your usernames and passwords. You probably have dozens of logins, so it's useful to keep them organized by type; click "My vault → New folder," and make some directories for different account types (social media, email, shopping, forums, and so on). Now click "Add a login," and fill in the form provided [**Image B**]. Bitwarden shows you the strength of your password as you type it. Click the eye icon to make sure you've typed the password correctly, or click the refresh icon to generate a new, stronger one. There's also an area to store notes, which are encrypted along with the username and password.

›› Add the rest of your logins in the same way. Now, whenever you visit one of those sites while logged into Bitwarden, the username and password fields are completed for you automatically.

3 SET DOMAIN EQUIVALENTS

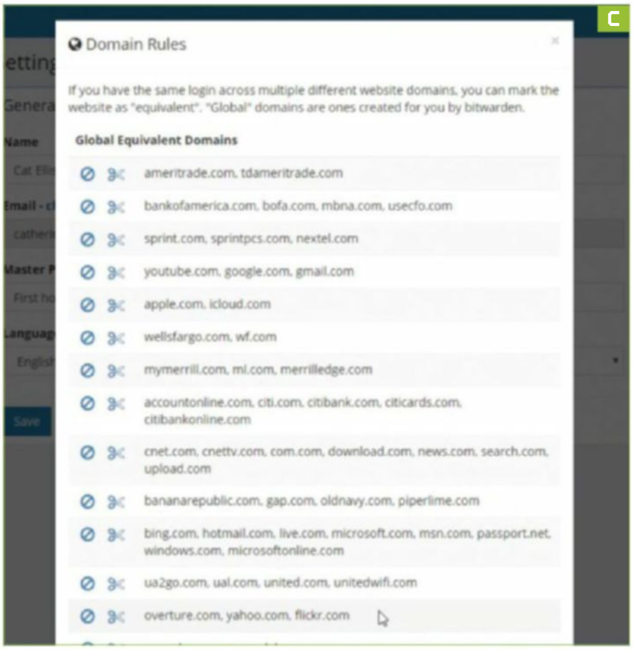
If you want to keep using the same logins for multiple accounts, you can connect them to avoid



Add New Login

Name *: Twitter
Folder: Social media
URI: https://www.twitter.com
Username: thecatellis
Password: ••••••••
Notes: These are some example notes that can be saved along with the account details

☐ Favorite



Domain Rules

If you have the same login across multiple different website domains, you can mark the website as "equivalent". "Global" domains are ones created for you by bitwarden.

Global Equivalent Domains

- ameritrade.com, tdameritrade.com
- bankofamerica.com, bofa.com, mbna.com, usecfo.com
- sprint.com, sprintpcs.com, nextel.com
- youtube.com, google.com, gmail.com
- apple.com, icloud.com
- wellsfargo.com, wf.com
- mymerrill.com, ml.com, merrilledge.com
- accountonline.com, citi.com, citibank.com, citicards.com, citibankonline.com
- cnet.com, cnettv.com, com.com, download.com, news.com, search.com, upload.com
- bananarepublic.com, gap.com, oldnavy.com, piperlime.com
- bing.com, hotmail.com, live.com, microsoft.com, msn.com, passport.net, windows.com, microsoftonline.com
- ua2go.com, ual.com, united.com, unitedwifi.com
- overture.com, yahoo.com, flickr.com

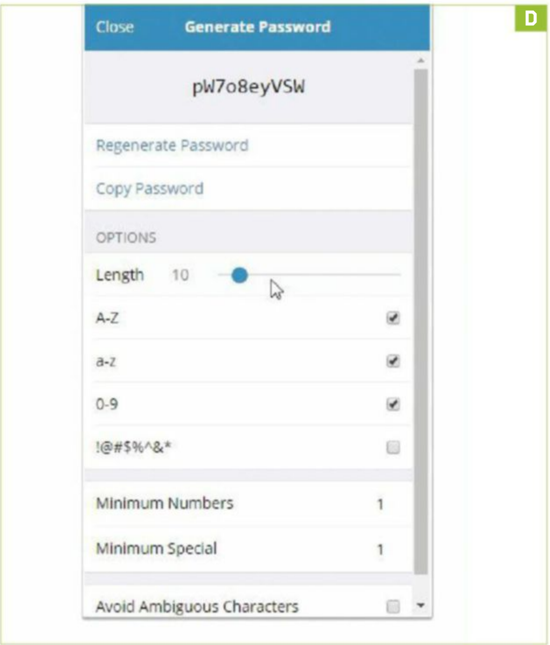
duplicating the effort of entering them. Set one up in your vault, then click "Settings → Domain rules." Bitwarden comes with a list of related sites that are likely to use the same login details—such as Google and YouTube—which can be toggled on and off [**Image C**]. To add your own equivalents, scroll right down to the bottom of the list, and click "Add new." Enter the domains you want to connect, separated by commas, then click "Submit." Note that you can only use "base" domains—not subdomains.

4 IMPORT AND EXPORT LOGINS

If you're moving to Bitwarden from a different password manager, you don't have to re-enter all your logins manually. Most password managers offer the ability to export your archived logins in CSV (comma-separated value) format. To add them to Bitwarden, select "Tools → Import" from your dashboard, then locate the file, and click "Import." If, for whatever reason, you decide Bitwarden isn't the tool for you, you can also export logins in the same way.

5 GET THE BROWSER EXTENSION

The Bitwarden browser extensions are a convenient way to manage passwords on the sites you visit, without visiting https://bitwarden.com to start a new browsing session. There are currently plugins available for Firefox, Chrome, and Opera—just search for "bitwarden" in the appropriate store, install it, and log in with your username and master password (plus a verification code from your phone if you've enabled two-factor authentication). Most of the features will be familiar from https://bitwarden.com, but the password generator [**Image D**] is a very handy extra tool that helps you make secure logins for sites that demand specific character counts or types. Click "Tools → Password generator," and use the checkboxes to choose whether the password should be upper case, lower case, or a mixture of both, and whether it should contain numbers or special characters (and how many).



Generate Password

pW7o8eyVSW

OPTIONS

Length 10

A-Z ☑

a-z ☑

0-9 ☑

!@#$%^&* ☐

Minimum Numbers 1

Minimum Special 1

Avoid Ambiguous Characters ☐

6 TRY BITWARDEN'S MOBILE APP

Bitwarden also has a mobile app for iOS and Android. Once it's installed on your smartphone, log in using your username, password, and verification code. Again, most of the features will be familiar, but there are some interesting extras. Tap "Settings" and you'll find additional security options, including the ability to log in with a fingerprint or PIN, and how long your session should remain active before it's locked and you have to re-enter your master password.

» To visit a site and log in, tap "Vault," then tap the site's URL, and it opens in your default browser. Bitwarden's developer is currently working on an improved auto-fill feature, but for the time being, you have to copy and paste passwords from Bitwarden into other apps. ⏻

REMOTE OR LOCAL VAULTS

There are lots of other password managers. Some, including KeePass, store your encrypted logins locally. This means you retain complete control of your logins, and you can access them offline, but setting up synching is complicated (the options are explained at http://keepass.info/help/v2/sync.html), and they're less convenient if you use multiple devices. Others, such as LastPass and Bitwarden, store your logins on remote servers after encrypting them. This is more convenient for multiple devices, but means you have to trust that the servers will remain up, and won't have their security compromised. In 2015, LastPass reported that user data had been stolen from its servers, including email addresses, password reminders, and authentication hashes. The hashes were sufficiently encrypted to prevent anyone accessing user accounts, but all users had to reset their master passwords to be safe. It's up to you to decide what your biggest priority is—however, since Bitwarden has far fewer users than LastPass, it's less likely to be a target.

Make Eye-Catching Polygonal Portraits

YOU'LL NEED THIS

PHOTOSHOP

Available from www.adobe.com.

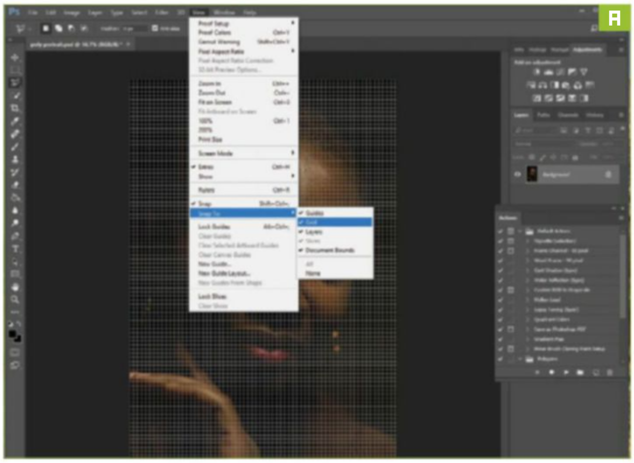
A SOURCE IMAGE

You need a portrait, ideally with a fair amount of background, to simplify the task.

BE WARNED: This is time-consuming. If you're not prepared to draw loads of little triangles, perhaps you should skip past. However, if that kind of work with Photoshop's Polygonal Lasso tool leaves you breathless with anticipation, this low-poly portrait is a great way to create a striking representation of a friend or loved one to hang on your wall or something. We just tell you how to make it, not what to do with it afterward.

You will, as ever, need a suitable source image to work with. We've chosen a full-face portrait of a beautiful young model, and halfway through the process wished we'd picked a different photo. Something with a little more background, not so tightly framed, would be faster to work with, due to there being less area to cover with triangles.

Whatever you choose, putting the time and effort into making the portrait will give you a fantastic final result, and tighten up some core Photoshop skills, such as pointer accuracy and use of a document grid, along the way. **–IAN EVENDEN**



1 ON THE GRID

First of all, let's set up the document grid. This will make it easier to keep our triangles together. Pull down the "Edit" menu, and select "Preferences → Grids, Guides, and Slices" [**Image A**]. Type in a figure for your grid spacing. For our picture, taken with a 16MP DSLR, we went for a gridline every 50 pixels, with subdivisions every 10. We also selected an off-white color and changed the grid into a pattern of dots, so the underlying image showed through better. Use "View → Show → Grid" if you can't see the grid. When it comes to drawing the triangles, this grid will make it easier to get them even, with their sides and points neatly lined up. Turn on grid-snapping ("View → Snap") to make it even easier, because your pointer will stick to the grid lines—we particularly recommend this, as we started out with good intentions, but soon drifted away from the grid while creating our triangle matrix. Later, we wished we'd had the self control to stay on the grid—you'll get a much better end result as a result of sticking to it.

2 ACTION STATIONS

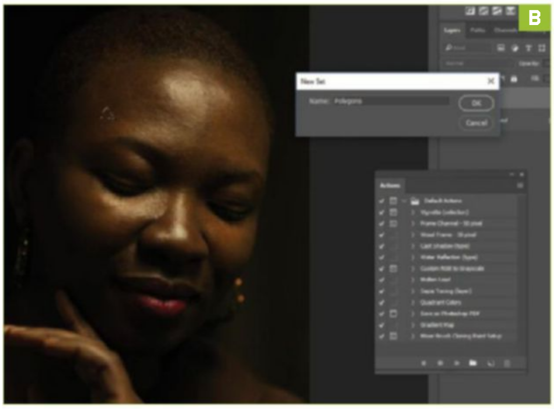
Next, we're going to create an Action. Actions are like the macros you can record on a good mechanical keyboard—sequences of commands that are played back on request. Photoshop's Actions can record mouse and menu events, as well as keypresses, and hotkeys can be assigned to play back an Action using a single button. Open the Actions palette using the "Window" menu, and place it somewhere convenient, so it doesn't get in the way. Draw a triangle on your photo using the Polygonal Lasso tool—it doesn't matter where—and hit the red "Record" button on the Actions palette.

3 RECORDING STUDIO

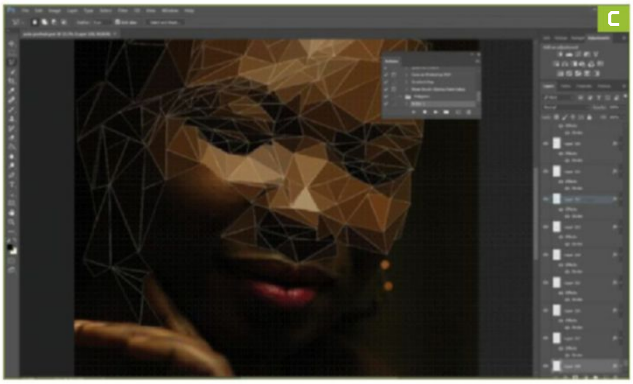
Follow this bit carefully, as it's being recorded. Copy your selection to a new layer (Ctrl-J or "Layer → New → New Layer via Copy") then, in the Layers palette, Ctrl-click the thumbnail of your new layer to load it as a selection. Then head to "Filter → Blur → Average," before deselecting with Ctrl-D (or "Select → Deselect"). Click the "Fx" button in the Layers panel, and choose "Stroke." Set Size: 1, Position: Inside, Blending Mode: Difference, Opacity: 100%, and set the color to white to make the edges clearer. Hit "OK," then click the "Stop" button on the Actions palette.

4 ETERNAL TRIANGLE

Give your Action a name [**Image B**], and assign a hotkey if you want—you'll use it a lot. Now to undo the changes to your photo caused by recording it. Delete the new layer, so you're left with only your Background layer. It's now time to start the painstaking process of covering your image with triangles. Draw one with the



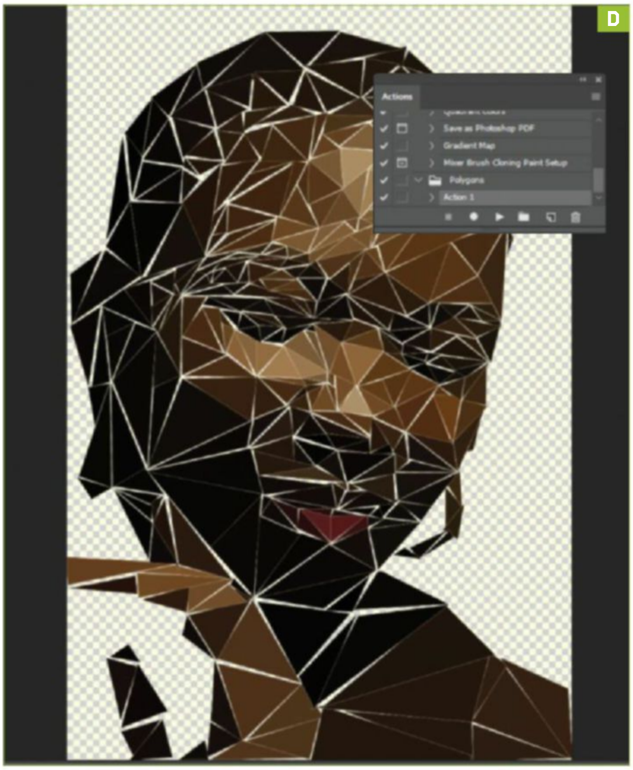
Name: Polygons

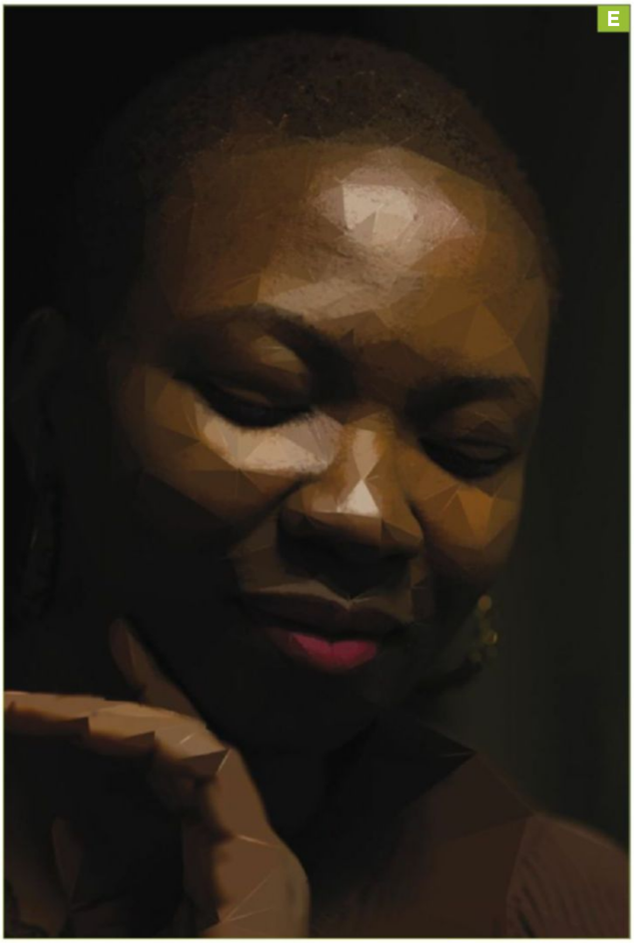


Polygonal Lasso, trigger your action, repeat. Every triangle ends up on a different layer [**Image C**], so if you get one wrong or want to tweak the effect later, you can. Save frequently as a PSD file, to preserve the layer structure, and remember you can double-click to complete a triangle once you've drawn two sides. Start at the edge with larger triangles, making them smaller as you pass over areas of more detail, such as the eyes. Hit Caps Lock to turn your pointer into a crosshair for more accuracy, and try to encompass areas of similar color within your triangles, as the Average filter isn't kind to contrasting skintones, rendering them muddy brown.

5 LAYER UP

Once you've finished all the triangles, you end up with a rather large file. Ours was 100MB and had 420 layers. As you can see from **Image D**, which has the Background layer hidden, we've ended up with slight gaps between our triangles, a result of not having enough discipline when snapping to the grid. It's still an interesting result, though, and by merging the triangle layers (Shift-select them all, then go to "Layer → Merge"), you can play with the blending of the triangles with the background.





6 FINISHING TOUCHES

We found that using the "Darken" blend mode (find it in the drop-down menu on the Layers palette) led to a striking blend of the two image styles, while "Divide" inverted many of the colors, and made it look like our model was caught in a nuclear fireball. Experiment with the blend modes, darkening the upper layer using Hue and Saturation's "Lightness" slider (Ctrl-U or "Image → Adjustments → Hue/Saturation"), or perhaps add extra triangles near the edges, to give the impression your subject is flying apart in a storm of polygons. Whatever you choose to do, remember to save your work often, and keep a layered PSD file of it for later tinkering [**Image E**]. ⏻

LASSO TOOL

The Lasso tool is used for selecting pixels. The Polygonal Lasso is its most structured form, fencing pixels off with straight lines, while the vanilla Lasso is a freehand tool. If you want to select using geometric shapes, head for the Marquee, which comes in rectangular and elliptical flavors, but sadly not as a triangle. The Lasso also has a magnetic variant, which attempts to stick to contrasting edges in your image, so you could, in theory, trace it around the edge of a house without having to be too precise. In practical use, however, it rarely ends up with the kind of precise selection you're looking for.

BUILD IT

ALAN DEXTER, EXECUTIVE EDITOR

Breathing Fresh Life into Old Gear

Your older hardware needn't be consigned to the scrapheap—put it to use in a patchwork PC

LENGTH OF TIME: **2-3 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

WE ARE ASKED to piece together machines all the time here on *Maximum PC*. These one-off projects are generally short-lived, and are designed to solve a particular problem or help elsewhere: a quick boost to a rendering farm, say, or to see whether a new graphics card or CPU really improves performance in a particular application. We also get more specific requests, such as a recent one to build a system for games coding. The caveat on this one was for a machine that they would get to keep—something we don't normally do because the components generally need to be returned to our hardware hoard for future builds. However, we were feeling benevolent, so set out to put some of the older gear to good use.

When it comes to coding, there aren't many specialist requirements above and beyond what you would want from a modern machine. A little more memory than the bare minimum helps, as does a speedy multi-core processor for compiling, and fast drives can make a difference when throwing around high-resolution assets. But, in general, any PC can turn its hand to the task. Still, it helps to know what the machine will be used for when picking components.

BEGGARS CAN BE CHOOSERS

THIS BUILD WAS A DEPARTURE from the norm, in that it wasn't a case of starting with a shopping list, then tracking down an ideal collection of hardware from which to build a glorious system. Instead, it was about looking at what was in the storeroom, what wasn't likely to be recalled, and what would work together to form a machine that was fit for purpose. So, we trawled through our spreadsheets and dusty cupboards for parts that were viable, if not exactly cutting-edge.

Our first port of call was the AMD FX-8370E, which is a reasonable enough processor, if not quite competitive with Intel's offerings. It's an "eight-core" chip that relishes multi-threaded environments, though it struggles at less parallel work. The price doesn't make a lot of sense either, which is why it's been languishing in our chip drawer, waiting for a moment to shine. We've slotted this into the MSI 970 Gaming, which is a thrill-free, but competent, board. For graphics, the Asus Strix 960 2GB is beginning to show its age, but it handles older games without a problem. The rest of the spec is fairly straightforward, with the exception of storage—where we'd normally use a spinning drive alongside a speedy boot SSD, we've employed another SSD for that task. This will help keep access speeds up, while providing plenty of space at the same time. It's a pricey solution, but it makes sense to focus the potential budget where it counts.

INGREDIENTS

PART		STREET PRICE
Case	BitFenix Shadow	$60
Motherboard	MSI 970 Gaming	$93
CPU	AMD FX-8370E	$190
Memory	Corsair Vengeance Pro 16GB (2x 8GB) @ 1,866MT/s	$120
GPU	Asus Strix 960 2GB	$162
PSU	EVGA 600B	$49
Storage 1	HyperX Savage 240GB	$124
Storage 2	OCZ Trion 100 960GB	$397
Cooling	Be Quiet! Shadow Rock Slim	$35
Accessories	2x BitFenix Spectre Xtreme	$40
Total		$1,270

1

COOL AND QUIET

WE ADMIT TO BEING OBSESSED with cooling, and adding more fans to a case is pretty much the first thing we do with any build. Easing more fans into the BitFenix Shadow was straightforward, as there's room for a pair of 120mm fans behind the front panel. We reached for a couple of the Spectre Xtremes, and screwed them into place after popping off the panel. We were squeezed for PWM fan headers on the MSI 970 Gaming, but didn't want the fans running at full speed all the time, as that would be unnecessary. This is why we attached the fans to the motherboard through a low-noise adapter (LNA), which reduces their running speed, so helps keep noise levels down. You can pick up a triple-pack of these from Be Quiet! for about $5, which is a decent investment.

2

FLOATING STORAGE

THE BITFENIX SHADOW CASE isn't exactly cutting-edge, but it's not a relic either, which is why we were surprised to discover that there's no easy way to mount SSDs in its monolithic form. There are plenty of drive bays, but the holes for the 3.5-inch bays don't line up with the mounting holes on our SSDs, and the tool-free brackets on the 5.25-inch bays don't fit either. Our solution was to screw the drives into place instead. Unfortunately, this was only possible in the 5.25-inch drive bays, but there's the obvious problem that we couldn't secure the drives in place from both sides, as we couldn't find a mounting bracket. We're not too concerned about the drives only being screwed in on one side, though, because SSDs are light, and won't move under their own weight.

3

OUT OF SIGHT

KEEPING YOUR CABLING OUT of the way is a good idea in any build, because it not only keeps the build looking tidy, but it also helps with airflow. Getting the ATX power cables to play ball can often be a pain, though, so you need to plan ahead with regard to how you're going to achieve this. Here we routed the EPS12V cable behind the motherboard, before actually installing the motherboard, so that it was completely out of the way. The main ATX power cable was a little easier to route, thanks to the section behind the drive bays that is designed specifically to help on this front.

4

FUN WITH BRACKETS

WE'RE SO USED TO INSTALLING all-in-one water coolers in our builds, that it was something of a shock going back to a straight air cooler. It worked well in practice, though—once we'd actually got it installed. We did need to install a holding bracket on the motherboard before we could use it, which we only realized after screwing the motherboard in place—learn from our mistake, and install the bracket first. Once done, however, the cooler clips into place relatively easily, even if space is a little tight. Installing the cooler before dropping the motherboard into place would have been a wiser move.

be quiet!
CORSAIR VENGEANCE
CORSAIR VENGEANCE

5

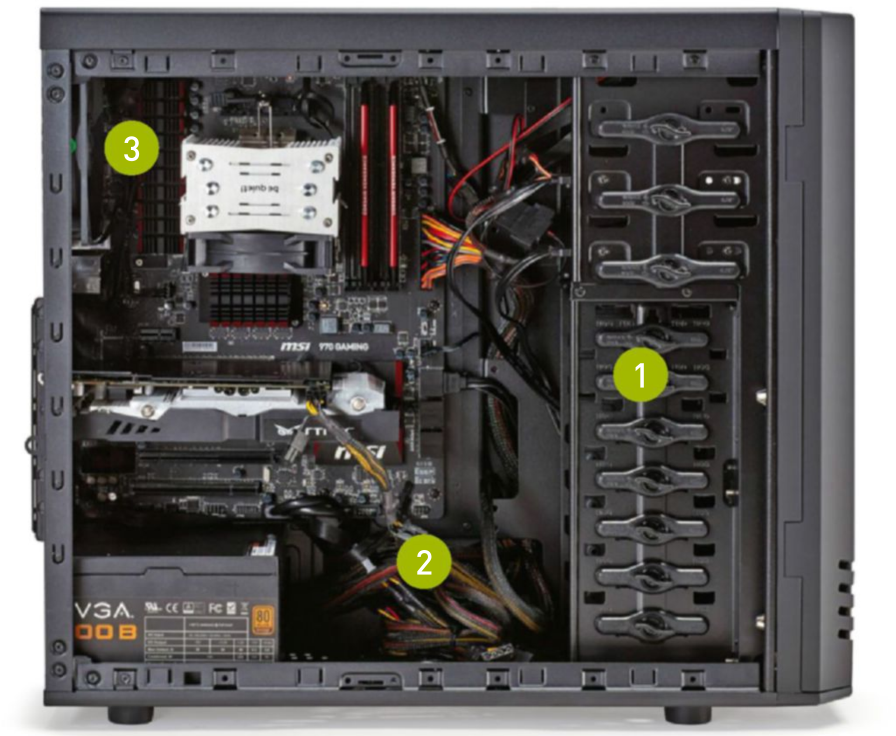
THE POWER OF CABLE TIES

THE TRICK WITH non-modular power supplies is knowing what to do with unused cables—hide them away, truss them up into a central column, or construct a coil out of them. Here we went for the final option, as there wasn't room to hide them behind the motherboard tray, and a central column wasn't needed. While a little unsightly, tying up the unused connectors with cable ties means they're kept out of the way in terms of airflow, but are available if you add additional hardware. Don't overdo the cable ties, though, as freeing a cable if you need it shouldn't be a chore.

6

GRAPHICS ON A BUDGET

IN A PERFECT WORLD, we'd kit out this machine with a card befitting premium games development: Something along the lines of a GeForce GTX 1080 or even a Titan X would be lovely. However, we can't afford to give such things away as though they're candy, so it was a case of installing what we had spare. The Asus Strix 960 is a solid card that can handle most games at 1080p with the settings dialed back a little. It's fair to say that upgrading this would offer up the biggest boost to frame rates, though, and there's plenty of room to support such a purchase. The EVGA 600B power supply supports dual eight-pin connectors as well, so no worries on that front.



1 These toolless drive bays are fine for traditional spinning and optical drives, but the mounting pins don't line up with SSDs. There's plenty of space if you do want to add more drives, though, and the fans behind the front door will help to keep them cool if you do.

2 The BitFenix Shadow case we've used doesn't have a side window panel, so while this isn't the tidiest build we've ever done, it's good enough in terms of airflow, and because no one can see inside, it doesn't need to look any better than this.

3 The case comes with a single fan installed at the rear, which we've left in place to help with the overall airflow—important when dealing with a traditional CPU air cooler.

THE START OF SOMETHING SPECIAL

WE'LL BE HONEST, this isn't a machine that is going to set the world alight in terms of raw performance. When you're piecing together a system using older parts, though, it's never really going to be anything else. You could argue, quite fairly, that a system built with development in mind should use the latest, greatest hardware. After all, when time is precious, scrimping on parts at the build stage will ultimately cost you in the long run. That would be true in a professional capacity, but this was actually built with an intern in mind, and because it uses a lot of older, unused parts, it's essentially free.

The build itself was fairly straightforward, with only the SSD mounting causing any serious head-scratching. The fact that those holes don't line up at all had us wondering whether we were doing something seriously wrong, but we simply couldn't resolve what was happening here. It could be that we were missing some holding brackets, which is a risk you take when you're using older hardware that may not be complete.

When it comes to performance, the machine may struggle to impress when compared to our default zero-point, but it's really not that bad a machine in normal day-to-day use. Those gaming frame rates are generally smooth, and with a few judicious tweaks here and there, you should be able to enjoy games for a few years yet. The *Deus Ex Mankind Divided* score is low, but that game does appear to thrash even top-end hardware as well—we would have hoped that some optimizations would have materialized by now, but nothing yet.

By the time you read this, AMD Ryzen will be out in the wild, and a quick look at the Cinebench score here shows that it couldn't have come soon enough. To be brutally honest, AMD's Piledriver is miserable when compared to Intel's offerings—even a Core i3 will give this chip a run for its money. At the lower end of the pricing spectrum, this can be forgiven, but at this price, we expect much more. It does have the raw core count when it comes to compiling and handling multiple threads, though, so isn't quite as bad as this benchmark would suggest.

We would recommend upgrading the graphics card, depending on what sort of game development the user intends doing with it, but this is a reasonable enough starting point. Apart from that, the core specification should last a couple of years, and with that large meaty data SSD, there should be plenty of space for textures, videos, models, and anything else needed. A bit more memory wouldn't go amiss, but again, as a starting point, this isn't too bad. The PSU should last a few upgrades as well. ⏻

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread	987	532 (-46%)
Cinebench R15 Single-Thread	196	90 (-54%)
CrystalDisk QD32 Sequential Read (MB/s)	1,895	536 (-72%)
CrystalDisk QD32 Sequential Write (MB/s)	949	514 (-46%)
Deus Ex Mankind Divided (fps)	25	15 (-40%)
Rise of the Tomb Raider (fps)	76	26 (-66%)
Far Cry Primal (fps)	72	35 (-51%)
Attila: Total War (fps)	39	20 (-49%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM. All games are tested at 1080p on max settings, with HD texture packages installed.

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REVIEWS

TESTED. REVIEWED. VERDICTIZED.

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CORSAIR K95 RGB PLATINUM
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See that? That's what awesome looks like.

AMD Ryzen 7 1800X

The Red Wedding

RYZEN HAS BEEN IN DEVELOPMENT for six long, arduous years, hand-crafted by the grand master architect himself, Jim Keller, and perfected by AMD's crack team of engineers. And since 2011, as AMD has had to weather Intel's aggressive, yet incrementally dull, Core-series storm, Ryzen has endured, flourished even, waiting to be unleashed. It's hard to deny how much hype Zen has generated, with many hoping and praying that it would shake up the market, and unseat Intel from its perch of pride. So, has it met our expectations? And is it worthy of the hype?

The AMD Ryzen 7 1800X is an eight-core, 16-thread, 14nm behemoth of a processor. Each core sports 64KB of L1 cache, followed by 512KB of L2 cache, and 8MB of L3 cache shared between each set of four cores, giving each R7 series chip a combined total of 16MB of L3. That last part is important: Instead of allocating 2MB to each core, the cache is shared across each set of four, so the processor can allocate memory to each core depending on how much it needs, without having to store that additional data externally in the memory itself.

So, what's the difference between all the 7-series chips? After all, each comes fully unlocked, and each comes packing eight cores, and 16 threads. It mostly comes down to two things: clock speeds and TDP. At the very bottom of the ladder (if you can even call it that) is the Ryzen 7 1700, with a clock speed of 3GHz at stock, boosting to 3.7GHz, given the right cooling, and a 65W TDP. Next is the 1700X, with a 3.4/3.8GHz clock speed, and a 95W TDP. And, lastly, the 1800X, still touting that 95W TDP, but with a base clock of 3.6GHz, turboing up to 4.0GHz when the situation demands. In short, you pay for better binned chips, but with a higher TDP. If overclocking isn't your jam, the 1700X is perfect; if you're after a content creator on a budget, the 1700 is ideal; and if you want the absolute maximum, you'll go for this little beauty, the 1800X.

MAKING SENSE

On top of the TDP and clock speed variance, the X-series processors come with AMD's latest SenseMi software suite, including one neat little inclusion in the form of XFR, or extended frequency range. Think of it as GPU boost for processors. Thanks to Ryzen incorporating over 1,000 different sensors into each chip, it can detect how much voltage is being directed to each area, and how well the chip is being cooled, then overclocks individual cores as necessary, boosting frequencies by 50–100MHz, depending on the application, cooling capacity, and utilization. Although not hugely impressive considering how little overclocking potential the R7 series has, it bodes well for AMD's future chip design.

Now the bit you've been waiting for: performance. For the price, it's incredible. Watching those 16 threads blazing away in Cinebench was a joy to behold. It absolutely smashed what we expected, scoring an astounding 1,612 in Cinebench R15, with single-core performance at an impressive 160 points—only 20 behind Intel's top-end Skylake chips. Other rendering benchmarks continued to impress, smashing figures by minutes in some cases. Power wattage was low for an eight-core part, though not quite as low as Intel's mainstream consumer chips—but those are still only four-core parts. Gaming was impressive, too: Across all our 1440p tests, we only saw frame rates differ by 1–2fps at most from the Intel counterparts.

That said, this chip is nothing if not unusual. Its aggressive price point, insane core count, and stunning performance only account for one part of its disruptive nature. Overclocking is also a mixed bag, with most 1800Xs only capable of maxing between 4.0 and 4.1GHz on all eight cores. But the real kicker is how the 1800X handles temperatures. With a 280mm AIO locked into place, we recorded idle temps at 50–60 C, which is ridiculously hot. We conferred with colleagues and other industry journalists, but they were seeing the same. However, weirdly, under 100 percent load across all eight cores, the 1800X topped out at 73 C, and then just held it there.

When all's said and done, the Ryzen 7 1800X is phenomenal. For the money, its performance dwarfs the competition, and shines a light on the profit margins Intel has been leveraging over the last few years. Disruptive? Definitely. Is AMD on top again? Time will tell. **–ZAK STOREY**

VERDICT
9
KICK ASS!

AMD Ryzen 7 1800X

+ HIGHZEN Stunning multi-core performance; mainstream accessibility; solid single-core support; advanced feature set; good TDP; insane price.

− LOWZEN Poor overclocker; temperatures not what we expected.

$500, www.amd.com

BENCHMARKS

	AMD Ryzen 7 1800X	Intel Core i7-7700K
X265 Benchmark (fps)	**27.89**	20.68
Cinebench R15 Single/Multi (Index)	159/**1,612**	**194**/970
FryRender Benchmark (m:s)	**2:41**	3:45
Power Draw Idle/Load (W)	56/182	**44/110**
Total War: Attila @ 1440p (fps)	39	**41**
Far Cry Primal @ 1440p (fps)	75	**77**
Rise of the Tomb Raider @ 1440p (fps)	**43**	**43**
Deus Ex: Mankind Divided @ 1440p (fps)	**13**	**13**

Best scores are in bold. All benchmarks were performed on the Asus Crosshair VI Hero AM4+ motherboard, with 16GB of Corsair Dominator Platinum memory at 2,400MT/s, and an Nvidia GTX 1080.

SPECIFICATIONS

Base/Turbo Clock	3.7/4.0GHz
Cores/Threads	8/16
Lithography	14nm
Cache	16MB L3
Memory Support	64GB DDR4
Memory Channels	2
Max PCIe Lanes	20
Graphics	N/A
TDP	95W

HERO
CROSSHAIR VI
ASUS
CROSSHAIR VI HERO
SUPREMEFX
START

It's beyond weird writing "Crosshair" instead of "Maximus."

Asus Crosshair VI Hero

Welcome to the AM4 chipset!

WITH ANY NEW INTEL processor comes a new and improved chipset, while every other generation brings a new socket type, too. This pushes people into a newer platform, while giving Intel the opportunity to reinforce the chipset with better connectivity options. And, of course, it gives AIB manufacturers the opportunity to reiterate their own motherboard designs. Jump ship to the red side of the fence, however, and the role has generally been reversed. AMD has always prided itself on maintaining a resolute socket type, requiring only a BIOS update to enable its latest performance powerhouses to operate with impunity. Which has meant that both chipset updates and connectivity have suffered.

With the launch of Ryzen and the AM4 socket, on the other hand, it seems this state of affairs may be changing in the rouge ecosystem. Taking a quick glance at AMD's X370 chipset and comparing it to Intel's Z270, you'd be justified in feeling slightly underwhelmed. By default, Intel's Z270 chipset supports 24 PCIe 3.0 lanes, six SATA 6Gb/s, 10 USB 3.0 ports, 14 USB 2.0 ports, and Intel Gigabit Ethernet. In contrast, AMD's X370 supports eight PCIe 2.0 lanes, four SATA 6Gb/s, two USB 3.1 Type C ports, six USB 3.0 ports, six USB 2.0 ports, and, once again, Intel Gigabit Ethernet. However, that's far from the full story. It's only when you take a look at what Ryzen (the processor) directly supports that you get a better understanding of how this platform will work going forward. By default, all of Ryzen's 7 series will support four USB 3.0 ports, four USB 2.0 ports, 16 Gen 3.0 dedicated graphics PCIe lanes (similar to its Intel Kaby counterparts), an additional four PCIe 3.0 lanes for "general use" (read: "NVMe SSD"), and an additional four PCIe 3.0 lanes for chipset communication. Which brings it exceedingly close to its Kaby competition, although without support for more than a single M.2 PCIe SSD.

Now let's look at the motherboard in question. Asus's Crosshair VI Hero is the first X370 mobo we've had in the labs for testing, and it's everything we want in a board. With support for DDR4 up to 3,200MHz, two 16 PCIe 3.0 slots, eight SATA 6Gb/s ports, a single M.2 PCIe x4 port, a plethora of fan headers, and a rear I/O that makes most Z270 boards look like a meal at your local Denny's, it's insanely good value for money. There's no integrated graphics support here, but to be quite frank, it's simply not needed with any of the three processors. The VRM solution is substantial, and having an eight-pin EPS power, plus an additional four-pin 12V CPU power, has allowed this board to clock up to 5.2GHz with some world-record-breaking chips. So, overclocking should be covered, if you luck out in the silicon lottery.

The biggest benefit the Hero has over its competition, though, is down to the socket itself. Namely, cooler support. AM4 has, rather annoyingly, come with an ever-so-slightly different mounting solution from its AM3+ predecessor's design. However, the Hero has mounting holes for both AM3+ and AM4 coolers.

Although we can't give any word on comparative performance just yet (at the time of writing, we're only two days away from our print deadline), overall it seems solid in contrast to the Intel alternatives, and we're happy to give it our seal of approval for anyone looking to get into the new AM4 platform. **–ZAK STOREY**

VERDICT **9**

Asus Crosshair VI Hero

➕ **SKILLSHOT** Fantastic rear I/O; strong overclocking support; DDR4 support up to 3,200MHz; multitude of fan headers; decent price.

➖ **BULLETSTORM** Lack of support for multiple M.2 drives; needs an additional USB 2.0 header on board.

$255, www.asus.com

BENCHMARKS

	AMD X370	Intel Z270	Intel X99
USB 3.1/3.0/2.0	**2/10/10**	0/10/**14**	0/**14**/8
SATA 6Gb/s	10 (or 8 + 1 NVMe PCIe SSD)	6	**10**
Memory Channels	Dual-channel	Dual-channel	**Quad-channel**
Max Memory Frequency	**2,666MT/s**	2,400MT/s	2,400MT/s
Number of PCIe 3.0 Lanes	20 (20 CPU, 0 chipset)	40 (16 CPU, 24 chipset)	**40 (40 CPU, 0 chipset)**
Number of PCIe 2.0 Lanes	**8**	0	**8**
NVMe PCIe SSD Support	1	**2**	**2**

Due to this being our first available sample, these benchmarks are combined chipset and processor comparatives between the X370, Z270, and X99 platforms. Best feature set specs are in bold.

SPECIFICATIONS

Chipset/Socket	X370/AM4
Form Factor	ATX
Memory Support	64GB DDR4 @ 3,200MT/s
M.2/U.2 Support	1x M.2 PCIe x4
SATA Support	8x SATA 6Gb/s
Max PCIe GPU Support	Two-way (x8, x8)
Rear I/O	8x USB 3.0, 4x USB 2.0, 1x USB 3.1 Type A, 1x USB 3.1 Type C, 5.1 audio, optical out, Intel Gigabit Ethernet

Lenovo Y900 RE

RGB as far as the eye can see

AFTER TESTING CRAZY multi-GPU setups for the past few issues, it was nice to kick back with a sleek, straightforward system. High-end machines are fun to play with, but their power levels (and price tags) are overkill for the majority of users, and SLI is becoming increasingly frustrating to deal with. This month, we're looking at the Lenovo Y900 RE, a mid-tower desktop featuring top-end (but reasonable) components, accompanied by a 27-inch Lenovo Y27g RE curved monitor.

The Y900 RE itself is a respectable system aimed mostly at gamers. The Intel Core i7-6700K CPU is clocked at 4.0GHz, but a "one-key turbo" button can push it up to 4.5GHz. That's enough to not bottleneck the GPU, and should be able to handle streaming or light video editing—though it would have been nice to see an updated Kaby Lake chip in there instead of last generation's i7-6700K. The difference isn't huge, but the i7-7700K would have given the system a bit more juice for basically the same price.

A bigger issue is the installed RAM—a single stick of 16GB DDR4-2133. To us, that's the weakest link of all the components, contributing to benchmark scores lower than our zero-point in all non-gaming tests: 790 in Cinebench 15, 18.68 in Tech ARP's x264, and 5,635 in PCMark 8 Creative (without CPU overclocking). Storage is handled by a 256GB PCIe SSD accompanied by a 2TB 7,200rpm HDD, the former scoring 42.26 and 165.1 in CrystalDiskMark64 4K read and write respectively—zippy, but again falling short of our zero-point. For gaming needs, the Y900 RE features a more-than-capable Nvidia GTX 1080, which handily gave us solid frame rates in all of our gaming benchmarks. The system pulled an average of 88fps across *Rise of the Tomb Raider's* three-part benchmark at 1080p max settings, scoring 131fps at the mountain peak, 71fps in Syria, and 61fps in the geothermal valley. *Far Cry Primal* and *The Division* also performed well, at 95fps and 92fps respectively—again at 1080p max settings.

Frame rates hovering in the 90–120 range fit perfectly with the bundled Y27g RE monitor, a 27-inch curved screen, with 1920x1080 resolution, and 144Hz refresh rate. The screen itself looks great, offering very good brightness and color, but might seem overpriced ($650) to some for only offering 1080p resolution. However, much of that price is due to the inclusion of Nvidia's G-Sync technology for variable refresh rates, which nicely eliminates screen tearing, even at those higher frame rates. Aside from being only 1080p, the biggest bummer about the Y27g is a lack of speakers. Monitor audio often isn't spectacular, but it's still a nice inclusion on a modern piece of equipment—especially at this price point.

RIDE THE RAINBOW

The RE stands for Razer Edition, because the Y900 RE comes bundled with a Razer Mamba Tournament Edition mouse and Blackwidow Chroma keyboard, and sports Razer branding and Chroma lighting integration. Both peripherals are great pieces of hardware—Razer's Deathadder Elite is one of our favorite gaming mice, and the Mamba offers everything that does, plus tilt buttons on the mouse wheel, as well as two extra buttons for DPI adjustment. Similarly, the Blackwidow Chroma features everything you want in a gaming keyboard: clicky mechanical switches, USB pass-through, mic/headphone jack, and a five-key macro column.

The Y900 RE comes in a sleek case that matches the Razer aesthetic. It feels relatively sturdy, made mostly of metal and plastic, and features a neat side panel that pops out when you press a spot on top. The main difference between the RE and the plain, non-Razer-branded Y900 (aside from the bundled Mamba and Blackwidow) is Chroma integration for the Y-shaped accent lighting. With Chroma support, the case lights can sync (or not) with the aforementioned mouse and keyboard, offering a bright array of colors and patterns. However, an equally spec'd plain Y900 is priced at $450 less than the Razer Edition, so it's up to you to decide whether a mouse, keyboard, and light show is worth the extra cash. **–BO MOORE**

VERDICT
7

Lenovo Y900 RE

+ RAINBOW CONNECTION Great 1080p performance; Chroma RGB lighting; easy overclocking.

− NO POT OF GOLD Monitor only 1080p; lacking in RAM; last-gen CPU.

$2,499 (+$650 for monitor), www.lenovo.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 (Index)	987	790 (-20%)
Tech ARP x264 (fps)	21.93	18.68 (-15%)
CrystalDiskMark 4K Read (MB/s)	54.85	42.26 (-23%)
CrystalDiskMark 4K Write (MB/s)	171	165 (-4%)
PCMark 8 Creative (Index)	7,675	5,635 (-27%)
Far Cry Primal (fps)	76	95 (25%)
The Division (fps)	78	92 (18%)
Rise of the Tomb Raider (fps)	41	88 (114%)
3DMark Fire Strike (Index)	15,026	15,859 (5%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point has a Core i7-6700K overclocked to 4.6GHz, an XFX Radeon R9 Fury X, 32GB of Kingston HyperX Savage DDR4-2400, and a 256GB Samsung 950 Pro, mounted on an Asus Z170i Pro Gaming mobo.

SPECIFICATIONS

Processor	Intel Core i7-6700K @ 4.0GHz
Graphics	Nvidia GeForce GTX 1080
RAM	16GB DDR4-2133 (1x 16GB)
Motherboard	Lenovo/TK
Primary Storage	256GB PCIe SSD
Additional Storage	2TB 7,200rpm HDD
Cooling Solution	Lenovo/TK
PSU	610W 80 Plus Bronze
Case	Y900 RE
Warranty	One year

The Y900 RE's Razer branding and suite of accessories pair nicely and look great, but at a price premium.

We've upgraded
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PNY CS2030 240GB

A serious alternative to Samsung?

IS THE MARKET FOR M.2 SSDs with support for the NVMe control protocol already a bit stagnant? You certainly get the sense that it's dominated by the usual suspects. More specifically, Samsung seems to have things sewn up with its 960 Pro drives.

So we extend a warm welcome to PNY with this, its entry-level enthusiast M.2 drive. It's powered by the Phison PS5007 NVMe controller, which has been shaking things up versus some arguably more established control chips, and hooks up via a quad-channel PCI Express 3.0 interface.

It's a quad-core controller, with some fairly lofty claims when it comes to internal house cleaning and in turn minimizing the performance delta between a full and empty drive. It also sports eight memory channels for maximum peak performance.

As for the PNY CS2030 itself, it uses relatively old-school 15nm Toshiba MLC planar or 2D NAND memory, instead of the more fashionable 3D TLC. That means lower data density, and it explains why PNY is only offering 240GB and 480GB models. To go beyond those capacities, PNY would have to opt for something larger than the M.2 2280 form factor seen here, which is 22mm by 80mm, to ensure compatibility with a broad range of systems.

The upshot in terms of the CS2030's on-paper capabilities at 240GB include claimed read and write speeds of 2,750MB/s and 1,500MB/s respectively, while IOPS come in at 201,000 and 215,000. For the record, its larger 480GB sibling rocks significantly superior numbers for random access performance, with IOPS at 300,000 and 270,000 for reads and writes.

NUMBER CRUNCHING

If that's how this drive stacks up on paper, what's it like when you throw some actual data at it? Pull some peak numbers with a test of throughput like ATTO Disk Benchmark, and you'll be impressed. With reads of 3.1GB/s and writes around 2.3GB/s, it not only exceeds PNY's own claims, it hands the Intel 750 and Samsung 950 Pro their derrières on a plate. It even trades blows with Samsung's 960 Pro 2TB.

Of course, ATTO is about as theoretical as it comes. Shift the focus toward more taxing synthetic and real-world metrics, and the picture is more mixed. The CS2030 is a whisker behind the older Samsung 950 Pro in CrystalMark, for instance, whether that's sequential or 4K random access performance, though the comparison drive in this case is a 512GB model. That said, the newer Samsung 960 blows this PNY drive away in CrystalMark sequential testing.

The CS2030 is also off the pace with our 30GB internal file copy benchmark. It's still seriously quick by broader SSD standards, but the comparison with the very best isn't flattering. Arguably more of a concern was our experience during pre-benchmarking preparations, which involve filling the drive with data, before deleting and allowing a little time for garbage collection to do its work. During the fill process, which mainly involves dumping large quantities of multi-GB video files from another drive on to the testee, the best SSDs maintain consistent performance. But not the CS2030. It kicks off at high speed, but can only sustain that for short periods, which indicates a significant role in buffering technology to achieve the impressive peak numbers.

All of which means the CS2030 is pretty solid, but it isn't quite a world-beater, and it needs to be cheaper to make a compelling case against the already entrenched SSD establishment. –JEREMY LAIRD

VERDICT

8

PNY CS2030 240GB

+ LIEUTENANT COMMANDER DATA Solid spec includes NVMe, PCIe x4 connectivity; good overall performance.

– BAD-BOY BROTHER LORE Can't quite compete with the best NVMe drives; fairly pricey; occasional performance flaws.

$180, www.pny.com

BENCHMARKS

	PNY CS2030 240GB	Intel 750 PCIe 1.2TB	Samsung 960 Pro M.2 2TB
Atto Sequential Read/Write (GB/s)	3.1/**2.3**	2.6/1.4	**3.4**/2.1
CrystalMark Sequential Read/Write (MB/s)	1,777/1,342	1,298/1,271	**2,636/2,077**
CrystalMark 4K Read/Write (MB/s)	50/197	37/**326**	**57**/194
5GB Zip (Seconds)	**193**	196	196
30GB Copy (Seconds)	54	42	**41**

Best scores are in bold. Our test bench consists of an Intel Core i7-7700K, Asus Maximus IX Hero, and 16GB of Corsair Dominator Platinum DDR4-2400.

SPECIFICATIONS

Capacity	240GB
Interface	PCIe 3.0 x4
Control Protocol	NVMe
Controller	Phison PS5007
NAND Type	15nm 2D Toshiba MLC
Sequential Read/Write	2,750MB/s, 1,500MB/s
Read/Write IOPS	201K, 215K
Warranty	Three years

Logitech G533 Wireless

Tireless wireless

BACK IN 1944, Supreme Court Justice Robert H. Jackson, when talking about slightly more important things than a wireless headset, said that, "The price of freedom … is that we must put up with, and even pay for, a good deal of rubbish." How right he was; while there's a lot to absolutely adore about Logitech's wireless G533 headset, there are also a few things you need to endure. So, let's get through those first.

Closed-back earcups are a bit of a science to get right. These wobbly, circa-30-degree twisters should, at least in theory, clamp down on a head of any shape. But we found an element of looseness, even after properly adjusting the decent ratcheted headband. You do settle in to the slightly sloppy fit after a while, though, but the same can't necessarily be said for the fabric. It's a rather rough mesh, fully washable, probably scientifically awesome, and we found it massively itchy. A good headset is one you forget you're wearing—this is a headset you feel like you're still wearing even some hours after taking it off.

The microphone offers up a double-strike of emotion. It's immensely cool in its design, clicking up flush with the right earcup to mute itself, hinging down satisfyingly, pulling out with a light tug, and not putting up a fight when you attempt to angle the bendy extension precisely where you want it to be. There's even a dim, subtle red light to indicate when it's muted. Beautiful. But then you speak into it. There's virtually no mid-point; with the extension fully sheathed, the mic isn't sensitive enough to satisfyingly pick up anything below an almost-shout, but when it's anywhere near your mouth, it's buzzy, clipping, and overpowered. It is possible to luck into a good position—and it's worth pointing out that, wherever it is, it's well pop-shielded, which is a major plus—but this is not a great mic by any means.

Audibly, things start to get a lot better. If we had to sum up the G533's mix in one word, we'd choose "clean." Thankfully, we have a few more words to play with: It's a clear, untouched sound stage, with none of the infighting you might find in other headsets, even at very high volumes. The software DTS 7.1 surround sound is fine, and every frequency gets the same chance to shine. While it's not as ludicrously booming or crunchy as some headsets, we come back to freedom; you're free to enjoy anything you like, with no sense this headset is meant for something else. You're free to tweak your own equalization in software, setting up personalized profiles on a per-game or per-program basis, and to do what you want with its entirely customizable button. And you're free to enjoy all this within a decent range of its simple USB dongle, with such little lag that it's completely imperceptible.

We never quite managed to walk the quoted 45 feet away from base. Our maximum range topped out at closer to 20 feet, in a busy office full of wireless interference, but that's not a bad result, and the connection never dropped or faltered while we were close. Pretty good, considering the battery life: Logitech quotes 15 hours, and we actually got 15 hours from a full charge at a reasonable volume. Battery test results matching a manufacturer's quote is almost unheard of, and the automatic power-off makes sure the G533 should be ready when you need it. If it's not, plug a micro-USB cable into the ear, and you can charge them as you listen. There are no jack options and, since it runs a proprietary lossless wireless protocol, the G533 is tied to your PC. Not absolute freedom, then, but freedom at a price that, depending on your preferences, could be worth paying. **–ALEX COX**

VERDICT 7

Logitech G533 Wireless

➕ **WIRELESS** Clean sound; great battery; decent range; software flexibility.

➖ **DIRE-MESS** Poor mic; odd fit and fabric.

$150, www.logitech.com

SPECIFICATIONS

Driver Type	40mm Logitech ProG
Impedance	32 ohms
Frequency Response	20Hz–20kHz
Microphone Type	Pressure gradient electret condenser
Connectivity	2.4GHz wireless
Range	Up to 45 feet
Battery Life	15 hours @ 50 percent volume
Weight	13.4oz

Corsair K95 RGB Platinum

Next up: gold-plated frames, and every key topped with rubies, sapphires, and emeralds

WE'RE FREQUENTLY TOLD that we can't have it all, but just as frequently, that's a lie. You can't work hard enough to attain a reasonable standard of living and still have a fulfilling life outside. You can't have jelly on your spaghetti. You have to choose. Corsair seems to disagree, as the K95 Platinum does, indeed, have it all. As long as you're prepared to stump up a frankly eye-watering amount of green.

Yes, for the price of a Radeon RX 480, you can get a mechanical keyboard with all the trimmings. Macro keys, Cherry MX Speed switches, RGB lighting inserted into places you never thought possible. Aircraft-grade brushed anodized aluminum. Eight whole megabytes of storage for swappable profiles. A detachable, double-sided wrist rest. An honest-to-goodness, proper USB 2.0 port, instead of a mere "charging" socket. A USB cable as thick as your finger, and a metal rolling volume control.

Visually, there's a hint of the HyperX Alloy FPS we liked so much back in the February issue about the K95 Platinum, its edgeless design meaning the keys stand out proudly from the baseplate, and you can inspect their undersides like an over-friendly drill sergeant. The drawback to this kind of design is that it mercilessly exposes any flaws in your keyboard hygiene routine: Blackened grot, bits of old fingernail, and the crumbs of too many hastily eaten burritos will work themselves into the mechanism, or just lie between the keys. The caps are easily removed for cleaning, exposing the gray stems of the MX Speed switches. These are clickless, like the more common Red variant, but activate after a mere 1.2mm of travel. The ubiquity of Cherry switches means the Platinum feels remarkably similar to other keyboards that use the same ones, but the light touch needed on the MX Speeds, mixed with the weightiness of the keyboard base, mean it's a board that lends itself to quick use, and would make a fine first mechanical keyboard for the novice or upgrader.

Every key is programmable, but the dedicated macro keys, separated on the left, are distinguished by a different color on top, and a textured and cambered surface—it is possible you might hit G3 while reaching for Tab, but you'll know what you've done the second your fingertip hits the top of the key. The rest of the alphabet has a smooth, concave top, the letter cutouts reassuringly large and letting through plenty of that RGB light. Not content with every key (except for the macro keys) having RGB LEDs underneath, Corsair has taken inspiration from its absurd MM800 RGB Polaris mouse mat, and run a strip of lighting round the back and top edges of the keyboard, too.

All of this requires programing, of course, and duties are held by the usual Corsair Utility Engine software. It's a nicely made bit of code that happily sits in the background, and can tie all your Corsair products together into one ungodly coruscating whole.

So, having it all is possible, as long as you're prepared to pay for it. There's not much to criticize about the Platinum—apart from the lack of actual platinum in its frame—except maybe that mandible-slackening price. At this level of outlay, you have to really want the Platinum. The original K95, with the same switches, goes for around $50 less; the K70 Rapidfire knocks even more off; and the HyperX Alloy, with glorious clicky MX Blue switches, is half the price. The siren call of the lighting and that useful USB port will have to be strong, therefore, to prevent passing corsairs lashing themselves to the masts of their ships, and sailing on past to less expensive waters. **–IAN EVENDEN**

VERDICT

9

Corsair K95 RGB Platinum

+ PLATINUM Well made; full-featured; a joy to use.

– UNOBTANIUM High price; perhaps overkill; only USB 2.0 pass-through.

$200, www.corsair.com

SPECIFICATIONS

Switch Type	Cherry MX Speed
Media Keys	Six plus volume roller
Macro Keys	Six
LEDs	RGB
Rollover	Full
Pass-Through	USB 2.0
Dimensions	18.3 x 6.7 x 1.4 inches; 2lb 14oz

ViewSonic XG2703-GS

Watch out Asus, ViewSonic is gunning for you

THANKS TO the aggressive prices of the latest UHD TVs, the value proposition of any given PC monitor is pretty parlous. Take the new ViewSonic XG2703-GS. For around $700, you get a paltry 27 inches of LCD panel, and a mere 2560x1440 pixels.

In UHD TV land, the astonishing reality is that $250 will buy you 40 inches and the full 4K complement of 3840x2160 pixels. That's nigh on one third the money for roughly twice the screen, by the major metrics.

Of course, UHD TVs are not directly comparable with PC monitors. What's more, ViewSonic's latest looks pretty clever next to what is arguably its nemesis, the Asus ROG Swift PG279Q. Both monitors check an awful lot of the same boxes. We're talking 27-inch, WQHD resolution, IPS panel technology, 165Hz refresh capability, and support for Nvidia's G-Sync adaptive frame synching tech. And yet the new XG2703-GS comes in at a full $100 cheaper than its Asus competition. Nice.

Indeed, ViewSonic has done a very nice job all round with its latest gaming panel. Straight out the box, it's immediately obvious just what a nicely calibrated monitor this is. The colors really pop, without being over-saturated, and both the black and white scales are pretty much pitch perfect. This thing has balance.

As you'd expect for an IPS panel, the viewing angles are super. More of a surprise, perhaps, are the subjectively deep and inky black tones. Contrast performance is above the IPS norm. We really like the smooth, clean anti-glare coating, too. There's hardly a whiff of that nasty grain and sparkle that blighted those IPS monitors of yore.

Likewise, support for up to 165Hz refresh just sweetens the deal, as does the lack of perceptible input lag, and G-Sync doing its buttery smooth thing in games. Add that to those rockin' colors, the clean panel coating, the top-notch viewing angles, and the super-smooth rendering, and you have a near faultless package. The chassis is also a nice break from the ViewSonic norm, and comes complete with some slick plastics and green accents that hint at the Nvidia G-Sync technology inside. The stand is fully adjustable, to boot, including rotation into portrait mode.

If you were determined to find fault, a little banding is visible in gradients, and the black levels can't quite compete with the very best VA panels. Likewise, the 165Hz refresh setting is buried under a very silly "overclocking" heading in the on-screen menu, which is annoying more than actually debilitating in any way. And the Asus Swift is superficially a bit snazzier as a piece of consumer electronics. That aside, there's virtually nothing in it.

With all that in mind, we're struggling to come up with compelling reasons to pay the extra $100 for the Asus. But still that UHD TV comparison is hard to shake. Indeed, there are some 40-inch 4K PC monitors, albeit somewhat UHD TV derived, that come in well under the price of this panel. Heck, there are middle-budget smartphones that can match its pixel count.

Part of the problem is no doubt the inclusion of G-Sync. It requires a proprietary module inside the monitor that adds at least $100 to the eventual retail price. The high refresh capability and the quality IPS panel all add to the cost, too. All of these are industry-wide issues, not things specific to this monitor, of course. But as nice a screen as this ViewSonic is, $700 still feels like one hell of a lot for a 27-inch PC monitor with mere WQHD resolution. Hopefully, the market as a whole will realize this sooner rather than later, and the price of this kind of high-performance 27-incher will come down a little. It needs to. –**JEREMY LAIRD**

VERDICT

9

ViewSonic XG2703-GS

+ FEAST FOR THE EYES Awesome IPS panel; outstanding all-round image quality; super feature set.

− FED ON FOOD STAMPS Expensive, depending on your view point; relatively modest panel size and native res.

$699, www.viewsonic.com

SPECIFICATIONS

Panel Size	27-inch
Native Resolution	2560x1440
Pixel Density	109 dpi
Panel Type	IPS
Maximum Refresh	165Hz
Response	4ms
Contrast	1,000:1
Display Inputs	DisplayPort, HDMI
Connectivity	USB, 3.5mm audio
VESA Mount	100 x 100mm
Warranty	Three years

Hard to fault, if it weren't for that price tag.

NZXT Kraken X62

The classy king of AIO liquid cooling

ALL-IN-ONES LIKE THIS ARE undeniably the future of processor cooling. They've come a long way over the last six years, from leaky, haphazard, nightmare-installation water blocks, to smooth, easy-to-mount, effective, bomb-proof pieces of equipment. So, what on earth could you do to make these things any better than they already are? After all, they've sported RGB lighting since the Corsair H100i days, and apart from improving fan design, and beefing up the thickness of the radiator, there's little, as far as we know, that can be done regarding performance gains.

So, appearance is the easier option to improve. But when you consider the size of the footprint you have to work on, what can you do to reinvigorate the looks department? What can you do to make people stop and think, "I really want that!" Well, if aesthetic redesign is the name of the game, there's no company better capable of capturing the hearts and minds of the prosumer audience than NZXT. Off the back of a phenomenal few years of launches, including the S310 Elite, the NZXT Manta, and the H440, when it comes to clean, slick-looking designs, NZXT has truly knocked Corsair off its perch.

Right then. The Kraken X62. NZXT's second iteration of its prestigious 280mm AIO cooler. Being one of the first to bring a full-fat 280mm liquid cooler to market, this second generation improves upon the first, not necessarily with any advancements in cooling technologies, but with aesthetic

improvements in the water block. All of NZXT's second-generation coolers come featuring an infinity mirror on the CPU block itself, and on the outside of that is situated a fully RGB light ring, with an RGB NZXT logo in the middle, and one of the most advanced RGB controllers we've encountered. Pulsing, rainbow waves, ripple effects, color-switching, or simply static, there's a true cornucopia of lighting profiles embedded into NZXT's free CAM software, making this the best-looking AIO we've ever seen.

Installation hasn't changed at all from the previous generation, and follows the usual fanfare associated with most mainstream AIO liquid coolers developed by Asetek. A simple plastic backplate slots through an Intel Z270 motherboard, followed by the four correct-length screws on the other side to lock it into place. Then it's just a case of placing the water block down, threading the other end of the screws through the holes on the block, and securing with the thumb screws. Job done. This new gen of Kraken comes with two additional cables that need to be installed on the block, one with the pump header and an additional four fan headers, and one micro-USB to internal USB to be plugged in and installed into the motherboard. This allows NZXT's CAM software to control fan profiles and LED lighting, and give you real-time feedback on other system resources.

Overall performance is similar, if not identical, to the previous generation of Kraken cooler. We saw a temperature variance of 1–2 C in most scenarios. However, that's well within margin of error and variances in air temperature. NZXT's new fan designs are also pretty slick. There's nothing fancy, in terms of RGB lighting, or anything out of the ordinary, and the max noise does peak up to 38dBA—which, for a 140mm fan, is pretty crazy. However, they do keep the AIO well chilled, and can be replaced with NZXT's RGB Aer fans if so desired.

Ultimately, the Kraken X62 is a well-crafted, beautifully stunning 280mm AIO. Yep, there may be cheaper AIOs out there, but we can tell you right now that you won't find one better looking or more complementary to any system. **–ZAK STOREY**

SPECIFICATIONS

Socket Compatibility	LGA 115X/2011(-3), AM4, AM3+, FM2+
Radiator Size	280mm
Radiator Thickness	30mm
Fan Airflow	61.4 CFM
Fan Noise	22-38dBA
Warranty	Six years

VERDICT

9

KICK ASS

NZXT Kraken X62

+ JÖRMUNGANDR Aesthetically stunning; solid cooling potential; reasonable price; good stock fans; decent warranty.

– SQUID A lot of cable to manage; protective cover hard to spot.

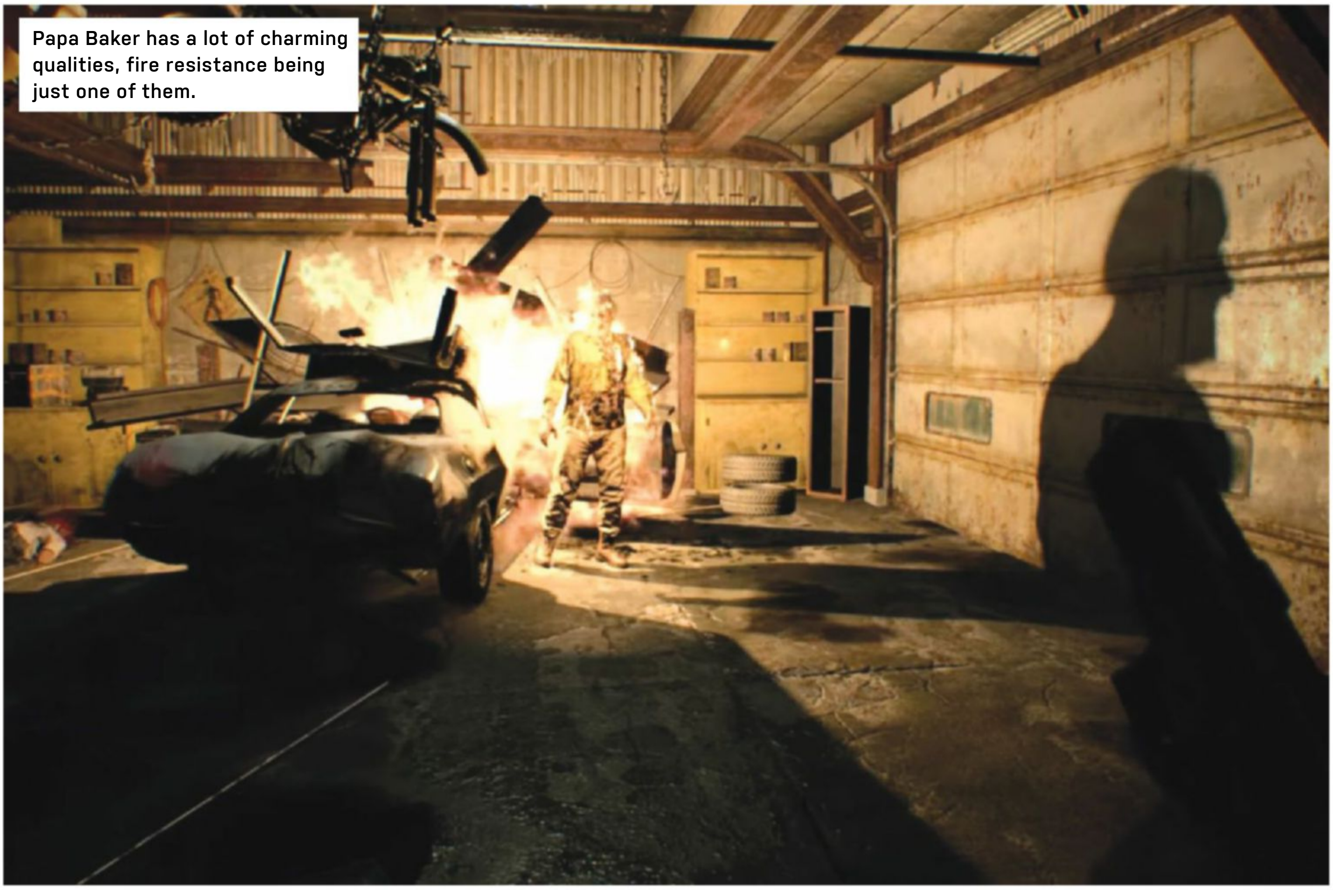
$160, www.nzxt.com

BENCHMARKS

	NZXT Kraken X62 + 2x Noctua AF14 Fans	NZXT Kraken X61 + 2x Noctua AF14 Fans
Idle Temperature	25 C	**22 C**
Prime 95 @ Stock	**55 C**	57 C
Cinebench @ Stock	**48 C**	49 C
Far Cry Primal @ Stock	44 C	**43 C**
Prime 95 @ 4.7GHz	**75 C**	76 C
Cinebench @ 4.7GHz	**62 C**	64 C
Far Cry Primal @ 4.7GHz	**51 C**	**51 C**

Best scores in bold. Our test bed consists of an Intel Core i7-6700K, a GTX 1080, 16GB of Crucial Ballistix Elite, and a 500GB Samsung 850 Evo SSD. All tests were performed for five minutes each, with a 10-minute cooldown period.

Oh, why can't we get this lit up in our photo shoot?



Papa Baker has a lot of charming qualities, fire resistance being just one of them.

Resident Evil 7: Biohazard

Fetch an umbrella, it looks nasty out there

RESIDENT EVIL 4 was quite good. However, the series has seen a bit of a downturn in quality since 2005, so hopes were high that Capcom could return to past triumphs with the seventh main-line game.

It certainly delivers. *Resi 7* is a break from the fast-headshotting crowd-control style of the past decade, dropping even the once-innovative over-the-shoulder camera in favor of good old first-person. The other thing that's changed is the globetrotting of *Resi 6*. *Resi 7* is tightly framed, much of its action taking place around one house in the Louisiana swamps. It's a throwback to the older games that were set in a lone mansion, but also a step forward, as it allows the designers to concentrate on puzzles and scares, rather than creating vast environments. Claustrophobia and isolation are very much the order of the day.

It's a good hour before guns are even introduced, and the feeling of vulnerability is cut by relief as you finally get something offensive, only to return as you realize how ineffective it is. Couple this with a save system from the 1980s—manual, and only in certain places—plus the series's notorious item-juggling, and the thought of what could be lurking around every dark corner gets very tense. (You can undo the work that's gone into the game's oppressive atmosphere by changing the gamma setting so everything's lit up like Times Square, but surely only a chicken would do that....)

The influence of cinema on *Resident Evil* has always been clear, but *Resi 7's* makers have been watching different movies. *The Texas Chain Saw Massacre* has been in the VCR as much as *Evil Dead*, with Leatherface's disgusting home informing the design of this old house. The derelict plantation's inhabitants come straight from that movie, too, while hanging totems evoke *The Blair Witch Project*, and the sultry, swampy, unsettling ambiance could come straight from season one of *True Detective*. The found-footage genre is particularly in abundance, thanks to collectable tapes that open side missions, in which you join the cameramen on their explorations.

Some things never change, however, and mysterious serums, bioweapons, and even a certain corporation all raise their mutated heads over the game's 15 or so hours. The new engine led to a VR version of the game on PlayStation. The thought of crashing around a room while trying to tear a Rift from our face almost makes us glad it hasn't yet made it to PC in this form.

Resi 7 is filled with ways to make the old feel new again. Its tight design, new engine, and keen understanding of how to unsettle the player make this one of the finest horror games to see the outside of a mysterious laboratory in living memory. –IAN EVENDEN

VERDICT **9**

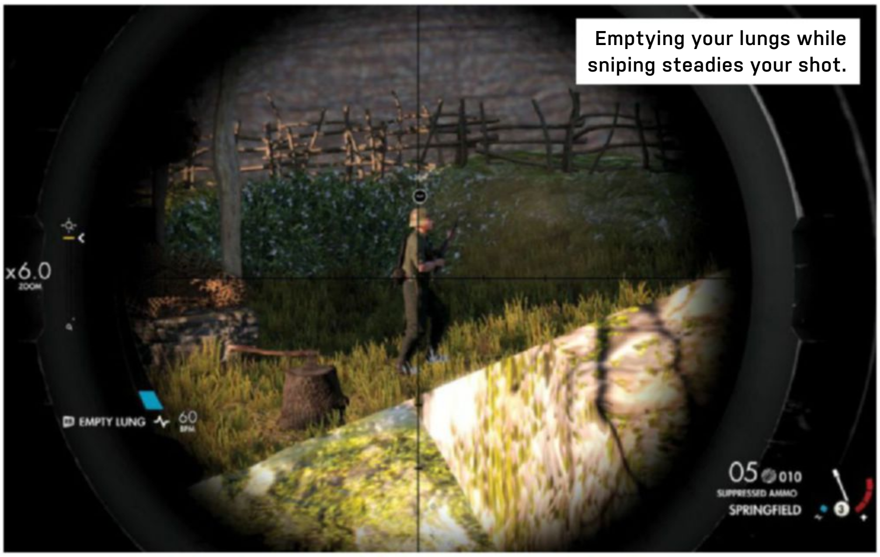
Resident Evil 7: Biohazard

➕ **THE HORROR** Brings series up to date with horror cinema; repugnance is rarely so well rendered.

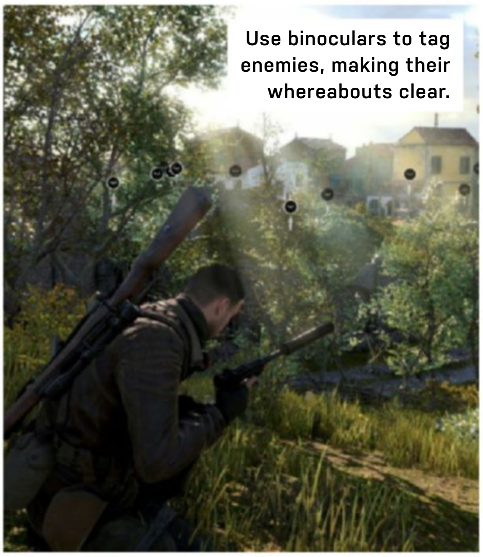
➖ **THE HORROR** Clunky save system; limited graphics options; no VR mode.

RECOMMENDED SPECS Core i7-3770 3.4GHz or AMD equivalent, 8GB, GeForce GTX 1060 (3GB+) or AMD equivalent.

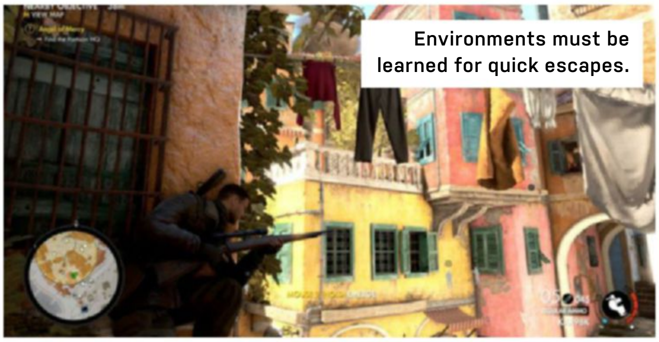
$60, http://residentevil7.com, ESRB: M



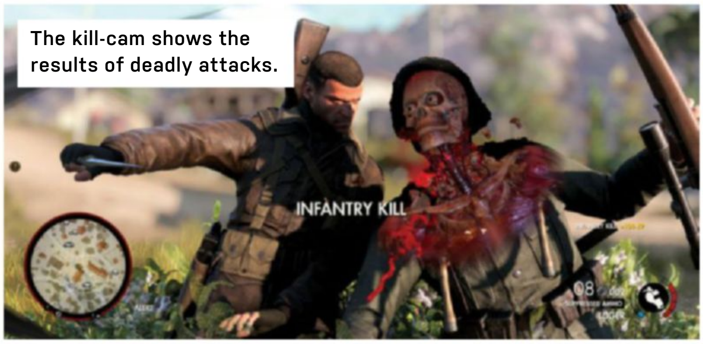
Emptying your lungs while sniping steadies your shot.



Use binoculars to tag enemies, making their whereabouts clear.



Environments must be learned for quick escapes.



The kill-cam shows the results of deadly attacks.

Sniper Elite 4

Man is the most dangerous game

THERE'S AN OBVIOUS POINT of comparison when considering *Sniper Elite,* Rebellion's sneak-around-and-kill-Nazis game: *Hitman.* But while IO's episodic title sees you travel the world in search of individual targets, in *Sniper Elite* everyone's game for a bullet in the skull. Because they're Nazis.

Dropped into a plot concerning Hitler's latest wonder weapon, Karl Fairburne finds himself in 1940s Italy, acting as a kind of one-man army. He totes a sighted rifle, plus a couple of secondary weapons, and a holdall of explosives with which he can blow his own cover. The game's main focus is on the rifle, and stealthy, long-range kills, but it also encourages you to get up close and personal by making you search corpses and slaughter everyone you come across.

The game's kill-cams keep up the entertainment. Get a hit on a particularly sensitive part of an enemy, and the camera circles round while the victim's skeleton is revealed, all bulging eyeballs and grinning teeth, showing the bullet tearing through bone or your knife slicing arteries. Knowing you're likely to trigger one of these gory mini cutscenes adds extra enjoyment as you see the crosshairs turn red.

On a second playthrough of a level, we discovered we could take out the mission's main target and a great many roaming soldiers from a tower, using a small supply of suppressed ammo and good timing to keep our location secret. Seeing their general lose his head and get stuck against a fence wasn't too much of a trauma for his bodyguards, who went on a brief, localized sniper-hunting spree before resuming their patrols in front of his cooling corpse.

This is the AI at its worst, but when you're in the thick of the action, its ability to search, as well as react to gunfire and unexpected sounds, means being discovered is always a possibility, no matter how well hidden you are. Italy's overgrown backyards and the patches of dense scrub on its more open plains mean it's possible to circumvent trouble by dodging from hiding place to hiding place, eventually settling on the perfect spot from which to sight your target.

Your secondary weapons, which start out as submachine guns and pistols but can be upgraded to shotguns or rocket launchers, mean running gunfights aren't out of the question. They're best entered into against small groups who can't call reinforcements, and out of earshot of larger bands, as a flow of troops into an area can ruin your fun, though a knowledge of your surroundings pays dividends if you have to run and hide.

Sniper Elite games may look like they're churned out on a production line, but this one shows genuine craft, and an understanding of what makes stalking your prey fun. That it also provides gory gratification just makes it easier to recommend. **–IAN EVENDEN**

VERDICT
8

Sniper Elite 4

⊞ **RIFLE** Gory kills; enormous levels; satisfying stealth.

⊟ **TRIFLE** Missions can get a little samey; locks guns behind DLC from the start.

RECOMMENDED SPECS Intel Core i7-3770 or AMD equivalent; 8GB RAM; Nvidia GeForce GTX 970 or AMD Radeon RX 480.

$60, www.sniperelite4.com, ESRB: M

LAB NOTES

ZAK STOREY, REVIEWS EDITOR

The Problem With Benchmarks

Or how you should take everything with a pinch of salt

IT'S THAT TIME AGAIN, when I have to begin looking at which GPU benchmarks we'll be using for the coming year. Our CPU and motherboard benchmarks had their revamp early in January, just as Intel and AMD began to launch their new platforms. And now, as we expect new GPUs to arrive over the next four months, it's time we banished some of our older benchmark titles, and invested in some new ones for our GPU suite.

The question is, which benchmarks should we use? Getting a healthy mix of both Nvidia and AMD sponsored titles is key, of course, to avoid any bias, and we'll need to nab some DX12 and DX11 tests, too.

But how do we test? There are two routes we can take: Either we can use an integrated benchmark, something akin to *Total War's Attila*; or we can use a custom, in-game run instead. The thing is, both methods have their downsides. Integrated benchmarks are often optimized to show a title running at its very best, and are never indicative of a scenario in game; while in-game benchmarks are trickier to perform, and infinitely more difficult to repeat in order to guarantee 100 percent accuracy.

This brings up an interesting point, especially when you're looking at our benchmarks, those of other publications, or even those of YouTubers. In reality, GPU benchmarks should always be analyzed only within the context of the one journalistic outlet from which they come, and taken with a pinch of salt. That's not to say people are fudging their numbers, just that the variance in test benches, how they perform the benchmark, what settings they use, and how they record those figures all varies so wildly that you can guarantee no two reviews ever look the same. That said, if you're looking to see where your system falls on those scales, your best bet is to use something like 3DMark's Fire Strike, or an integrated benchmark for which you know the graphical profile settings your favorite reviewer uses, and go from there.

Benchmark Summary
Exit Benchmark

The *Total War* benchmark, in all its GPU-judging, graph-centered glory.

TUAN NGYUEN

Editor-in-Chief

I recently saw a video where a gaming enthusiast managed to install *Doom*—yes, the game—on his Porsche's in-dash entertainment system. At first, I thought this was really cool. Unfortunately, to control and move the protagonist, the driver had to use his Porsche's steering wheel, and drive the vehicle around. I can't stress enough how dangerous this is. While it may be a cool exercise to try to install *Doom* on your car's computer, it's just another vector for bad things to happen. Technology is always being added to cars to make driving safer, but a lot of drivers fail to even use their car's turn signals, and that's a standard technology available on every car. Basic life things first; cool tech later.

BO MOORE

Technology Editor

As you've no doubt realized, we spend a lot of time talking about—and getting excited about—crazy high-end systems on *Maximum PC*. However, right now, I'm actually psyched about the low end. That's largely to do with the Intel Pentium G4560, a low-end processor that gives you just enough power to not bottleneck your graphics. Of course, you're not going to pair a $600 GPU with a $60 CPU—that wouldn't make a whole lot of sense—but dropping the G4560 into a budget gaming build means that you can put together a GTX 1060 or RX 470-powered system for less than $500. A system that'll hold down 60fps at 1080p without breaking a sweat. Finally, a true console-killer.

Editors' Picks:
Digital Discoveries

Alan Dexter, executive editor, and Jarred Walton, senior editor, ponder future gear

THE COMPLETE RYZEN LINE-UP

At the time of going to press, we don't have all the Ryzen chips in the labs, because only three have been released so far. Those first three are the headline-grabbing performance parts that do a convincing job of butting up against Intel's finest—particularly in the multi-threaded arena. Check out the full review of the AMD Ryzen 7 1800X on page 76, and we'll have a deep dive into the more interesting aspects of AMD's new chip next issue, plus a review of the Ryzen 7 1700X.

These aren't the chips I'm most excited about, though, because I like a bargain. Which is why the Ryzen 5 and Ryzen 3 have piqued my interest. We won't see the seriously-budget-focused Ryzen 3 until the second half of the year, but we should see the Ryzen 5 this side of summer.

The Ryzen 5 1600X is a six-core, 12-thread chip running at 3.6GHz (4GHz Turbo), while the Ryzen 5 1500X is a quad-core, eight-thread chip thrumming along at 3.5GHz (3.7GHz Turbo). Both are intriguing, but it's the six-core chip that I'm desperate to drop in a system. Pricing is obviously vital to any assessment, but given the most-affordable Ryzen right now is $329, we should have a decent Core i5-beater on our hands.

$TBA, www.amd.com

GEFORCE GTX 1080 TI

Nvidia has just revealed its latest and greatest graphics card, and it's a doozy. The GTX 1080 Ti cranks the dial all the way to 11—literally. It uses the same GP102 GPU as the Titan X, with the same 3,584 CUDA cores, but it comes with 11GB of GDDR5X memory, clocked at 11Gbps. It also has higher GPU clocks than the Titan X, and a price that replaces the old GTX 1080 Founders Edition. Speaking of which, there will be 1080 Ti FE cards, but they won't be priced any higher than the custom cards.

So, the Titan X has become a status symbol that's no longer the fastest GPU on the planet. The 1080 Ti will outperform it by around five percent—unless you can find a workload that uses more than 11GB of memory but less than 12GB, and does so in a way that puts the Titan ahead of its more cost-effective sibling. This is also the most powerful Ti card, relative to the stock 1080, with performance over 30 percent higher.

Nvidia has used improved GDDR5X yields to hit 11Gbps, and has reworked elements of power and cooling. Using the same 220W load, Nvidia says the 1080 Ti cooler can run 5 C lower than the 1080, or be 2.5dB quieter. Don't fret if you couldn't justify the cost of the Titan X; the 1080 Ti is a Titan-killer.

$699, www.nvidia.com

GEEK TESTED & APPROVED

Philips GoLITE BLU Energy Light

OUR OFFICES are in the throes of renovation, to create a more corporate-friendly, "hot-desking" environment. Great for those in HR, finance, and other more malleable positions, but for us, with multiple test benches, a pool of monitors, and a ton of hardware, it's less than convenient. So, we've been relegated from our sunny fourth-floor haven into the dark basement. Leaving our old home was depressing enough, but coupled with the lack of sunlight, our moods have plummeted.

Philips heard of our plight, and sent us a care package, including this GoLITE BLU Energy Light. We've never had much faith in SAD lamps—after all, nothing compares to basking in the rays of that thermonuclear reactor in the center of our solar system—but we approached this, er, light bulb with an open mind.

According to Philips, it's "clinically proven to increase energy levels and mood." Use it for 20–30 minutes a day, and you're all pepped up and ready to go. It comes in white and blue variants, depending on what kind of light you appreciate—the blue is meant to simulate a summer's sky. Does it work? Well, journalists are, by default, cynical, and in a trade that's currently fighting in a corner, raising any mood is a challenge. That said, there was a noticeable difference in mood the longer we had this on. It's not a perfect replacement for sunlight, but for those willing to dish out the cash to give their mood a boost, this might be the lamp for you. **–ZS**

$150, www.philips.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Upgrading GPUs
> Boot Speeds
> Upgrade Choices

Upgradeable GPUs

This topic comes up quite a bit in the magazine, but ever since I bought my first Intel quad-core CPU, I've been off the clock, so to speak, when it comes to upgrading motherboards and CPUs in tandem. Never quite satisfied, and always feeling behind the cutting edge, I've hit my budget for now at a Z97 with a Core i5-4690K. Lately, I'm seeing the speed of video cards running the same pattern. For instance, an upgrade to a 4GB GTX 960 early last year is already choking on anything but 16:9 frame rates. Do you think we'll ever see the great Red versus Green teams introduce technology where we're upgrading a video card, rather than changing them out completely each year or two? **–Ryan Anthony**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Keeping bang up to date with the latest technology can be a pricey pastime, but, realistically, very few of us live on the cutting edge, or indeed need to. If you're happy with your system's performance—or you're happy to dial back the settings in order to keep the frame rates smooth enough—that's all that really matters. However, when it comes to upgrading, we generally recommend going with the latest and greatest gear, because that will last you the longest time until your next upgrade.

As for Nvidia and AMD changing the way they make and sell graphics cards, I can't see this happening any time soon, simply because the rate of progress is still so incredible. Both companies have big plans on the memory front at the moment, and that affects pretty much everything about the design of the next generation of graphics cards. This, coupled with the fact that the graphics card market is quite healthy right now, suggests that the situation isn't going to change any time soon.

Speedier Boot Times

Interestingly, while reading your March 2017 issue, I noticed Zak Storey's article entitled: "Boot Times." He speaks about the lengthy boot times that seem to be associated with using the newer PCIe SSDs or M.2 drives as a boot device.

I found this not to always be the case. I have an MSI Z270 Gaming M7 board, with a shiny new Core i7-7700K, and I am using a Samsung 950 Pro as my boot drive in the middle M.2 slot (with the latest Samsung NVMe driver). The only BIOS settings I changed from default when I installed the M.2 (and Windows 10 Pro) were to enable the Windows 8.1/10 WHQL Support, and disable the MSI Fast Boot, as recommended by users on their forums.

My system boots in about nine seconds from button-press—slightly faster than my previous build, which had a Samsung 840 EVO SSD as the boot drive. Obviously, there are a plethora of variables here, but depending on what motherboard you are using, and what particular BIOS settings, a PCIe SSD can be a blazing-fast boot device. Try hitting the john before my system is ready after pressing the power button. I hope you can pee fast!
–Ken Browning

REVIEWS EDITOR ZAK STOREY RESPONDS: I've seen plenty of speedy boot times over the years, using a variety of hardware, which is why it struck me as being so odd that one of my builds was struggling so much. I tried various things to sort out the problems, but in the end swapped out the motherboard—which, as an aside, proved that it wasn't the SSD at fault.

Juggling Upgrades

Love the magazine. I suspect I am one of your older readers, as I am 77 and still building my own PCs. I have a rig that was pretty high-end when I built it several years ago, but it's getting a bit long in the tooth now. Here are its specs:

- Intel Core i7-2600K
- Asus P68-V Pro Gen 3 motherboard
- 16GB Corsair 1600 DDR3 RAM
- Asus Radeon HD 7970 Direct CUII TOP GPU
- Antec HCG-900 900W PSU
- Crucial M500 960GB SSD
- 2x WD Black 7,200rpm 2TB storage drives
- LiteOn DVDRW LH-20A1L optical drive
- Asus VW222 1680x1050 monitor
- Windows 10 Home Premium

I do routine Word and Excel tasks, web browsing, fairly sophisticated photographic editing with Photoshop CS5 Extended, and occasional video editing

↘ submit your questions to: comments@maximumpc.com with basic tools such as AVS Video Editor. And, of course, I like to play top-title games of various genres at high-quality settings.

Although I'm satisfied with how my rig handles all of the stuff I do, I would like to replace my monitor with a 27-inch 2560x1440 one, perhaps an Asus ROG Swift PG278Q.

Question 1: Do you think the problems surrounding the use of 4K monitors will soon be resolved, and that it would be a mistake to purchase a 2560x1440 monitor at this point?

Question 2: If you think a 2560x1440 monitor is a good choice, what do you think of the Asus ROG Swift PG278Q in particular? Would you recommend it, or perhaps something else?

Question 3: Do you think my rig would provide adequate frame rates in demanding games at high settings on a 2560x1440 monitor? I suspect not, so…

Question 4: Although I'd love to build an entirely new rig with all the latest goodies, my wallet won't support that at this time. I'm wondering whether I can rock a new 2560x1440 monitor simply by replacing my GPU with a current top-end Nvidia GTX 1080 GPU of some ilk, and get by until the rig is just not up to the demands of next-gen games. Then, when I do eventually replace the CPU/mobo/boot SSD/memory and so on, I could continue to use the 2560x1440 monitor and GTX 1080 GPU, perhaps adding a second GTX 1080 in SLI (that is, unless at that point they, too, have become obsolete).

So, what do you think? I'd appreciate any and all advice you can offer.

–Salvatore Mazzone

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: The "problem" with 4K is that we haven't yet seen a monitor that checks all of our dream screen boxes—high refresh rates, HDR, perfect size, and 4K panels simply don't exist right now. They're coming, but they're going to be pricey, and if you're looking to buy a graphics card at the same time, then your budget may well be stretched to breaking point. Driving that many pixels isn't easy either—even the best cards right now can struggle in some games at the highest settings at 4K.

Grabbing yourself a beefy GTX 1080 certainly won't hurt your options, though, and we still have a weakness for a good quality 2560x1440 screen—so, yes, we would find it quite easy to get behind your suggestion of upgrading your graphics card now, and coupling it with a quality 1440p panel. The Asus ROG Swift PG278Q is a good TN panel, but it is getting a bit old now, and we've seen a few competing screens pop up that have tickled our fancy a touch more—such as the IPS AOC Agon AG271QG (currently on Amazon for $620) that we reviewed in our January issue, or there's the ViewSonic XG2703-GS, which you'll find reviewed this issue on page 86.

Beating the Budget

I have been an avid reader of *Maximum PC* for a while, and it is a great magazine, but I just wanted to point out some flaws with the $300 budget build article. I feel that by just picking parts at MSRP, you are not only not making the best out of the budget, but also encouraging people to do the same. I have built two PCs—one last year for me, and one this winter for my friend, who wanted to get into PC gaming. They were both built with a budget of $325, and I was able to get an Intel Core i3-6100 and R9 270X, and an AMD Athlon X4-860K and R9 380 in each of them respectively, with 8GB of RAM. I spent a lot of time picking out the parts, and bought most of each build from Craigslist. This includes the case, PSU, RAM, and the R9 270X. This just shows that if you really want a decent cheap build, it is possible if you just work to find good deals and used parts. **–Keegan Pelton**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: While I agree with your sentiment, in practice there are plenty of things that make it a tricky route to follow in the magazine—one-off sales that aren't available by the time we go to press aren't much use to the vast majority of our readers. There's also the problem with hardware not working and not being covered by warranties, or being tricked by the more unscrupulous sellers. Having said all that, we genuinely do see this as a great way of making tight budgets stretch that little bit further. This also touches on a challenge we've been meaning to do for a while now—seeing how much machine you can get second-hand for the very smallest of budgets, and what you need to spend to turn them into full-fledged systems. Watch this space.

Dead Pixels

As Ultra HD monitors have more pixels than 1080p Full HD ones, do they get more dead pixels? And, therefore, do they have a shorter lifespan? **–Rusoha**

SCREEN EXPERT JEREMY LAIRD RESPONDS: While you're correct that, in theory, Ultra HD has a greater risk of dead pixels, I can't remember the last time I saw one—and I see a lot more screens than most. There is the point, as well, that as the pixels get smaller and smaller, the impact is less obvious—in fact, unless a pixel was stuck on bright near the center, you'd be hard pushed to spot it most of the time. This doesn't generally affect the lifespan either.

[NOW ONLINE]

HOW MUCH RAM DO YOU REALLY NEED FOR GAMING?

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How much RAM do you really need for gaming? Time was that 4GB was more than enough for gaming and most daily tasks, but those days are in the past. If you have too little RAM—4GB, say—there's a good chance that a lot of the games you want to play just won't run, or at least won't run well. *Mass Effect: Andromeda,* for example, lists 8GB of RAM as the required minimum, falling in line with many other modern games. And even for those that have a minimum of 4 or 6GB, 8GB is definitely recommended, because other programs on your PC run in the background. http://bit.ly/1xlbsmO

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THE BUILDS

BUDGET

INGREDIENTS

PART			PRICE
Case	Phanteks Enthoo Evolv ITX		$70
PSU	EVGA 450B Bronze		$45
Mobo	MSI B250I PRO Mini ITX		$90
CPU	Intel Pentium G4600		$86
GPU	EVGA GeForce GTX 1060 Gaming 3GB	**NEW**	$190
RAM	8GB (2x 4GB) G.Skill NT Series DDR4-2400	**NEW**	$58
SSD	256GB SanDisk Z400s	**NEW**	$85
HDD	1TB Hitachi Deskstar 7,200rpm 3.5-inch SATA		$44
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit		$16

Approximate Price: $684

THERE AREN'T A LOT OF CHANGES for our budget rig this month, with only the fight against increasing prices forming any serious difference. Pricing for the 3GB spin of the 1060 continues to be volatile, with last month's choice seeing a $10 price bump, so we've gone for the EVGA card this month instead. RAM pricing continues its upward spiral, too, but we managed to grab a pair of G.Skill sticks for a reasonable price. SSDs are mimicking this trend as well, forcing us to swap out to one of SanDisk's Z400s again—a solid budget option that we've used before. It's hard to say for sure why there's been a 5 percent price drop on the Pentium G4600, because we suspect that the launch of Ryzen hasn't impacted Intel's budget offering, but you never know. We expect more shifts in pricing over the next few months, though, so it definitely pays to shop around a bit. Overall, our budget build saw its price tag increase by $22.

MID-RANGE

INGREDIENTS

PART			PRICE
Case	NZXT S340 Elite		$100
PSU	EVGA SuperNOVA 550 GS Gold		$83
Mobo	MSI Z270 Gaming M3		$160
CPU	Intel Core i5-7600K		$240
Cooler	Corsair H100i v2		$110
GPU	Zotac GeForce GTX 1070 Mini 8GB	**NEW**	$375
RAM	16GB (2x 8GB) G.Skill V Series DDR4-2400		$99
SSD	256GB Intel SSD 600p M.2 PCIe		$100
HDD	Western Digital Blue Series 1TB 7,200rpm		$50
OS	Windows 10 Home 64-bit OEM		$100

Approximate Price: $1,417

AT THE TIME OF WRITING, Newegg has a deal that shaves $10 of the usual retail price of the Core i5-7600K. Normally, we avoid such short-lived offers, but in the case of the Core i5, you can assume there will be rolling deals for a while, as Intel responds to the release of Ryzen. Elsewhere, we've switched graphics card vendor again this month, because Zotac's compact GeForce GTX 1070 saw a healthy price cut. It also comes with your pick of either *For Honor* or *Ghost Recon: Wildlands*. This deal is spearheaded by Nvidia, and it's a common sight when picking up a new graphics card; although it's worth noting that they are often time- or game-limited. Graphics card aside, the machine is identical to last month's build, with a few subtle price tweaks here and there—RAM increased a little (no surprise), as did Corsair's H100i V2, but the savings on the GPU and CPU meant that, overall, we managed to save $8 compared to last month's build.

TURBO

ALL CHANGE AT THE TOP. We did briefly consider holding off on recommending Ryzen so soon after release, but we've been so impressed by the performance that we feel the need to endorse it from day one. The Ryzen 7 1800X boasts two more cores than the 6800K that it replaces, which means software has four more threads to play with—a significant difference for plenty of high-end applications.

A new processor means a new motherboard. At this stage, it's hard to know for sure whether the Asus Crosshair VI Hero is the best available, but it checks plenty of boxes when it comes to features and overclocking potential (even if Ryzen doesn't seem to want to overclock too much). On the memory front, we've gone a slightly different route to Intel's quad-channel offering, picking up a pair of 16GB Vengeance LPX DDR4-2666 sticks, for a total of 32GB—plenty for high-end work. We've also picked up the newer Kraken X62 cooler, because it's one of the first to support AMD's new AM4 socket.

The other notable change is on the graphics front: Prices for the GeForce GTX 1080 have dropped to around the $500 mark since Nvidia announced that the GeForce GTX 1080 Ti was on the way. While the 1080 Ti will undoubtedly be the card to lust after the moment it hits the shelves, that shouldn't detract from the fact that the straight 1080 now offers great value for money. In fact, this DUKE rendition boasts a healthy overclock of 1,708MHz (101MHz over the base clock).

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART			PRICE
Case	Phanteks Enthoo Evolv ATX	**NEW**	$170
PSU	EVGA SuperNOVA G2 750W		$117
Mobo	Asus Crosshair VI Hero	**NEW**	$255
CPU	AMD Ryzen 7 1800X	**NEW**	$500
Cooler	NZXT Kraken X62 280mm AIO	**NEW**	$160
GPU	MSI GeForce GTX 1080 DUKE	**NEW**	$500
RAM	32GB (2x 16GB) Corsair Vengeance LPX DDR4-2666	**NEW**	$245
SSD	1TB Samsung 960 Pro M.2 NVMe SSD		$660
HDD	2x 2TB WD Black 7,200rpm 3.5-inch SATA		$244
OS	Windows 10 Home 64-bit OEM		$100

Approximate Price: $2,951

UPGRADE OF THE MONTH

AMD Ryzen 7 1800X
AMD
RYZEN

AMD RYZEN 7 1800X

It's hard to state exactly what kind of effect Ryzen has had on the entirety of the processor ecosystem, but we'd put good money on it putting Intel on the back foot. This is likely to be the end of the quad-core processor being the norm for the mainstream, and not soon enough, we say. The Ryzen 7 1800X is the core that started this revolution, bringing HEDT-class performance at an affordable price point. The chipset may not be perfect right now, and AMD's definitely going to be working on those teething problems, but for the price, that pro-grade performance is nothing short of exceptional.

$500, www.amd.com

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